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LIST OF PAPERS

Paper I.

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Paper II.

Solberg, P. A., Hopkins, W. G, Ommundsen, Y., & Halvari, H. (2012). Effects of three training types on vitality among older adults: A self-determination theory perspective. *Psychology of Sport and Exercise*, *13*, 407-417

Paper III.

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Paper IV.

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SUMMARY

Background: With an increasing population of older adults there has been increased interest in the fields of both science and politics in improving older adults' ability to live a valuable and independent life (WHO, 2002; Nelson et al., 2007). Being physically active and exercising seems central improving quality of life and preventing institutionalisation among older adults. However, little is known about how and for whom exercise influences older adults' well-being. Few studies have examined several types of training simultaneously, and hardly any have included a psychological theory when investigating well-being outcomes among older adults. Such information is important if we are to create effective interventions in the future, and to increase activity among older adults.

Objectives: A multidisciplinary study was conducted with the overall aim of investigating the effects of three types of exercise on muscle strength, physical function and indices of well-being among older adults. This thesis examines the effects on well-being. Secondly, there was an aim to identify and test possible mechanisms for the exercise–well-being effect with variables suggested by self-determination theory (SDT; Deci & Ryan, 1985a; 2000).

Methods: A 16 week randomised parallel group exercise trial involving a total of 138 older adults ($M = 74.2$ years, $SD = 4.5$, 68% women) was performed. Participants were recruited through posters and newspapers, and randomised to an endurance training group, a functional strength training group, a traditional strength training group, or a wait-list control group. Measurements were performed at baseline, at week 7, at week 16 and 12 months after cessation.

Results: At week 7, there was a small beneficial effect of functional training on life satisfaction and vitality, a small beneficial effect of strength training on vitality

and a moderate beneficial effect of endurance training on vitality. Endurance training also had a small beneficial effect on vitality over the whole trial (16 weeks) and small beneficial effects on vitality, positive affect and negative affect at follow-up (16 months).

Short term change (0 to 7 weeks) in autonomous motivation and perceived competence mediated the beneficial effect of exercise on vitality over the trial (0 to 16 weeks), while change in controlled motivation negatively mediated the effect of exercise on both subjective well-being and vitality. Change in need for competence partially mediated the positive effect of functional and strength training on vitality at week 16, while for endurance training, competence only did so for those with high perceptions of autonomy support. The positive effect of endurance training on vitality was moderated by perceived autonomy support in the short term and functional training in the long term. Participants' baseline regulation of motivation moderated the long-term outcomes of the trial, with those being autonomously regulated exhibiting higher well-being and physical activity at follow-up, compared to those with controlled forms of regulation.

Recommendations: With an expanding older population, the present trial provides important information about possible mechanisms of the exercise–well-being effects among older adults. Endurance training can be recommended. In addition, competence and quality of motivation seem particularly important in explaining why and for whom exercise increases well-being among the elderly.

DEFINITIONS OF CENTRAL CONCEPTS

Physical activity is defined as “any bodily movement produced by skeletal muscles that results in energy expenditure” (Caspersen et al., 1985, p. 126). *Exercise* is a subcategory of physical activity “that is planned, structured, repetitive, and purposive in the sense that improvements or maintenance of one or more components of physical fitness is an objective” (Caspersen et al., 1985, p. 128). Throughout the dissertation “training and exercise” is used when the protocol is planned, structured and repetitive (such as the present intervention). “Physical activity” is used when there is reference to studies measuring activities which may also involve housework, gardening and shopping.

Mental health is a broad term defined as “a state of well-being in which every individual realises his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community” (WHO, 2011). The term *well-being* is considered the most important part of the overall quality of life or mental health of an individual (Spirduso et al., 2005). Huppert (2009) stated that “well-being is about lives going well, a combination of feeling good and functioning effectively” (p. 137). Similarly, Ryan and Deci (2001) refers to well-being as “optimal experience and functioning” (p. 142). Therefore, well-being is more than the absence of ill-being (Diener et al., 1999; Huppert, 2009). In the present work, well-being is referred to as a positive mental state, and most studies included in the thesis involve positive mental states. Studies involving negative mental states, such as depression or anxiety, are only included when necessary.

A mediator is “a variable that accounts for the relation between the predictor and the criterion” (Baron & Kenny, 1986, p. 1176). *A moderator* is “an interaction variable that affects the direction, strength, or both of the relationship between physical activity and the outcome” (Bauman et al., 2002, p. 8). A mediator is considered to be a change happening during the intervention, and a moderator is often considered to be an individual or group variable. Mediators typically explain how and moderators clarify for whom the intervention affects the outcome. In this thesis the term *mechanism* is used for both concepts as it provides information beyond a possible direct effect.

Note that when there are more than two authors in a study, the abbreviation “et al.” is used from the first time it is referred to in the text. When there are two authors, both are cited every time.

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INTRODUCTION

Statistics Norway (SSB, 2003) estimate that the number of Norwegians aged 67 years or more will double in the next 40 years. Unfortunately, increased age does not necessarily mean increased quality of life in the later years (McAuley & Morris, 2007; Spirduso et al., 2005). Several physical changes are observed as people age, such as reductions in muscle strength and mass (Macaluso & DeVito, 2004), aerobic capacity (Weiss et al., 2006), and increased body fat and chronic conditions (Chodzko-Zajko et al., 2009; Nelson et al., 2007). These physical changes may have great individual and societal costs. For example, in 2001, those aged 65 years or more accounted for 45% of medication use and 47% of hospital capacity, although they constituted only 16% of the Norwegian population (FHI, 2009). Consequently, there has been a great political and research focus on improving older adults' capacity to live a valuable and independent life (Chodzko-Zajko et al., 2009; Nelson et al., 2007; WHO, 2002, 2009).

Many of the physical changes and chronic conditions occurring with increased age can be reversed with physical activity. In addition, physical activity can improve mental health among older adults (Arent et al., 2000; Chodzko-Zajko et al., 2009; Nelson et al., 2007; Netz et al., 2005; WHO, 2009). High levels of well-being have in turn been related to lower risk of disability and mortality, better physical health, more fulfilling relationships and higher performance (Chida & Steptoe, 2008; Lyubomirsky et al., 2005; Penninx et al., 2000; Ryff et al., 2004). At present, levels of physical activity seem to decline with age (Biddle et al., 2012). One study in Norway estimated that only 6% of the living-at-home population aged between 65 and 97 years satisfied the recommendations of 30 minutes moderate activity 5 days per week (Loland, 2004), while a later study using

objective measures estimated that about 20% of people aged 65 to 85 years met the recommendations (Hansen et al., 2012). Feeling well by exercising or being physically active is important because it is likely to enhance the chance of continued participation and thereby increase future health (Benyamini et al., 2000; Standage & Duda, 2004). Therefore, investigating the effects of exercise and physical activity on well-being among the elderly is regarded as an important area for research.

In contrast to the physical changes, age per se is not directly related to decreases in mental health or well-being (Kunzmann et al., 2000; Ryff, 1989). Hence, the effect of physical activity on well-being is expected to operate indirectly (McAuley & Morris, 2007). Unfortunately, little is known about how physical activity increases well-being (Buckworth & Dishman, 2002; McAuley & Rudolph, 1995; Rejeski & Mihalko, 2001). With more knowledge about effective mechanisms we can design better interventions to increase well-being and levels of activity (Biddle & Nigg, 2000; Standage & Duda, 2004). The present research was carried out to improve our knowledge about how exercise might influence well-being among older adults by investigating three different types of training and examining the role of mediating and moderating variables suggested by self-determination theory (SDT; Deci & Ryan, 1985, 2000).

THEORETICAL BACKGROUND

Psychological well-being

Because of the beneficial effects of exercise, good mental health and high well-being, these variables and their relationships have been an important factor in research and politics relating to the elderly. However, there is no universally acknowledged definition of well-being in the literature. What does it mean to be psychologically well? The question has interested researchers and philosophers for centuries and there is no room for a full discussion of the term here. This chapter defines well-being as applied in the present study, and finishes with a rationale for the choice of concepts and measures.

As there are differences in how people define their well-being and what makes them feel well, one definition that encompasses all seems difficult to produce. Consequently, several terms have been used in describing well-being in the literature. Some examples are; “quality of life” (Rejeski & Mihalko, 2001; Spirduso & Cronin, 2001), “health-related quality of life” (Kelley et al., 2009; Rejeski et al., 1996; Ware et al., 1992), “psychological well-being” (McAuley & Rudolph, 1995, Netz et al., 2005; Ryff & Keyes, 1995), “mood” (Arent et al., 2000), “subjective well-being” (Diener, 1984; Diener et al., 1999), and “eudaimonic well-being” (Ryan & Deci, 2001; Ryff, 1989; Ryff & Keyes, 1995).

The different constructs may create confusion, but they all try to define what it means to function well and feel good. Two things are generally agreed upon: 1) well-being is a multidimensional phenomenon (Kunzmann et al., 2000; McAuley & Rudolph, 1995; Netz et al., 2005; Ryan & Deci, 2001), and 2) well-being should not be equated with the absence of ill-being (Huppert, 2009; Keyes & Lopez, 2005; Ryan & Deci, 2001).

In the psychological literature two different views of well-being have emerged, and together they cover both components in Huppert's (2009) and Ryan and Deci's (2001, see definitions) view of well-being: the hedonic is concerned about "feeling good" (Diener, 1984; Diener et al., 1999), while the eudaimonic approach is concerned with an individual's ability to "function effectively" (Ryff, 1989; Ryff & Keyes, 1995).

Hedonic well-being

The hedonic view emphasises the subjective experience of the individual, and is often equated with happiness (Kahneman, 1999; Ryan et al., 2008). Diener's (1984) concept of subjective well-being (SWB) is typically considered hedonic. SWB is defined as "a person's cognitive and affective evaluation of his or her life" (Diener et al., 2005, p. 63). Cognitive evaluation is referred to as a person's satisfaction with life (Pavot & Diener, 1993), while "affect" reflects current mood and emotions, and is labelled pleasant or unpleasant (Diener et al., 1999; Watson et al., 1988). People use current available information when evaluating life satisfaction, and therefore a measure of affect is often included in research (Diener et al., 2003). In addition, positive (PA) and negative affect (NA) have different correlates (Emmons & Diener, 1985), and enhancing or reducing one of them may not ensure high subjective well-being. Therefore, SWB is considered the experience of high life satisfaction and positive affect together with low levels of negative affect (Diener et al., 1999, 2005).

Eudaimonic well-being

The eudaimonic view is not particularly about happiness, but more about what it means to be "optimally functioning" (Ryan et al., 2008; Ryff & Keyes, 1995; Waterman,

2007). Ryff and Keyes (1995) question whether the concept of happiness (or SWB) covers what it means to be psychologically well. Their critique of the hedonic view is based on the fact that most people, even the disabled and the unemployed, report being happy. In addition, they state that the realization of goals, which is an aspect of positive function, often requires effort that can be incompatible with short-term happiness. Ryff and Keyes (1995) therefore suggest that well-being should include six components proposed to tap the multidimensionality of a person: self-acceptance, personal growth, purpose in life, positive relations with others, environmental mastery and autonomy. In that way, eudaimonia differs from SWB in that it focuses more on the processes leading towards optimal functioning, rather than the outcome (Ryan et al., 2008).

Rationale behind the concepts of well-being used in the present study

Because the well-being concepts have been applied interchangeably, or without a theoretical rationale, several authors have requested a justification for the selection of concepts or measures used (Bowling, 2005; Ekkekakis & Petruzzello, 2000b). The different concepts are related but still distinct, and they may have different antecedents (Nix et al., 1999). Consequently, it has been difficult not only to find consensus in the research, but also to identify mechanisms explaining how exercise influences well-being among the elderly (Rejeski & Mihalko, 2001). There were four main reasons for using well-being and incorporating both the hedonic and eudaimonic approach in the present study.

Firstly, well-being was chosen because many previous exercise studies have included measures of negative aspects of mental health such as depression or anxiety (Netz et al., 2005; Penninx et al., 2002; Singh et al., 1997). Indeed, more research on how

exercise can influence the positive aspects of older adults' mental health has been suggested (McAuley & Rudolph, 1995; Netz, 2009; Netz et al., 2005).

Secondly, since well-being is ascribed to both optimal experience and function (Huppert, 2009; Ryan & Deci, 2001), the hedonic and eudaimonic approaches together cover this conception.

Thirdly, several previous exercise studies have used the SWB concept (life satisfaction and affect) when assessing well-being (e.g., Katula et al., 2008; Mihalko & McAuley, 1996). In addition, these scales have often been used in large epidemiological studies of the elderly in the western world (Kunzmann et al., 2000) and Norway (NorLag, 2006; Daatland & Hansen, 2007). By using the same concepts, results could be compared with previous studies and the scales had been tested among older adults in Norway.

Fourthly, self-determination theory was used as a framework and SDT typically embraces both the hedonic and eudaimonic view of well-being (Ryan & Deci, 2001). Therefore, several SDT-based studies have included both well-being constructs and thus predictors of well-being have been theoretically operationalised through previous research (e.g., Edmunds et al., 2007a; Nix et al., 1999; Wilson et al., 2006a). In addition, Ryan and Frederick (1997) have developed a vitality scale that is considered a eudaimonic measure of well-being. This scale was adopted because Ryff and Keyes' (1995) model involves several terms which SDT considers precursors of well-being (Ryan et al., 2008). Further, the quality of life scales (e.g., SF-36; Ware & Sherbourne, 1992) include several different components which may be antecedents of well-being (e.g., subjective health), and therefore make it difficult to identify mechanisms (Rejeski & Mihalko, 2001). Hence, the subjective vitality scale (Ryan & Frederick, 1997) and the

SWB-scales (Pavot & Diener, 1993, Watson et al., 1988) were adopted as indicators of well-being in the present study.

Exercise and well-being among older adults

The increased attention to the relationship between exercise and well-being in older adults over the last two decades is reflected in many reviews (e.g., McAuley & Rudolph, 1995; McAuley & Morris, 2007; Rejeski & Mihalko, 2001; Rejeski et al., 1996; Netz, 2009; Spirduso & Cronin, 2001; WHO, 2009) and recent meta-analyses (Arent et al., 2000; Kelley et al., 2009; Netz et al., 2005). This chapter is not an attempt to produce a new review, but rather to present an overview of findings and point to areas where more research is needed to understand the relationship even better.

What do we know?

In cross-sectional and longitudinal studies, active older adults consistently report higher well-being than those less active (e.g., Bertheussen et al., 2011; Bize et al., 2007; Stewart et al., 1994). Two meta-analyses also report small positive effects of exercise on mood (Arent et al., 2000) and quality of life (Netz et al., 2005). Thus, exercise seems to influence older adults' well-being, but the effects are small. At the same time, many randomised exercise trials do not report substantial changes in well-being among the elderly (e.g., Blumenthal et al., 1989; Chin et al., 2004; DeVreede et al., 2007; Peel et al., 1999). These equivocal findings have been discussed in relation to the sample under investigation (Blumenthal et al., 1989, 1991; Chin et al., 2004; King et al., 2000), the different scales used to measure well-being and their sensitivity in healthy populations (Bize et al., 2007; DeVreede et al., 2007; King et al., 2000), the duration of the

interventions (Blumenthal et al., 1989, Mihalko & McAuley, 1996), the type of exercise implemented (Netz, 2009), and the lack of statistical power (DeVreede et al., 2007; Katula et al., 2008). In addition, few trials have included mechanisms, and more theoretically-driven research on the mechanisms behind the relation has been requested (Buckworth & Dishman, 2002; McAuley et al., 2000a; McAuley & Rudolph, 1995; Rejeski & Mihalko, 2001; Netz et al., 2005).

There are two ways a mechanism can work to influence well-being: it can be a mediator or a moderator. Several mechanisms have been proposed in the literature and I will discuss in more detail those most relevant to the present study.

Mediating mechanisms

A mediator is typically a change occurring during intervention and provides information about why exercise increases well-being (Kraemer et al., 2002). Mediators can be both physiological and psychosocial (Landers & Arent, 2007; Netz, 2009).

Physiological mediators

It is proposed that the physical changes occurring through exercise can influence feelings of well-being. The most common physiological explanations are the physical improvement (fitness) hypothesis, the cardiovascular hypothesis, the monoamine-hypothesis, the endorphin hypothesis and the temperature hypothesis (see Landers & Arent, 2007, for an overview). Many of the physiological mechanisms are poorly understood, mainly due to measurement issues, and individual differences in hormones and response to exercise (Landers & Arent, 2007). Therefore only the physical fitness hypothesis is elucidated further. The fitness hypothesis is based not only on cross-

sectional findings linking good health to higher well-being (Hillerås et al., 1998; Kunzmann et al., 2000), but also on past studies reporting a positive relation between poor physical health and depression (Morgan, 1969). Physical improvement may be of extra importance for older adults experiencing a decline in strength, muscle mass, physical function and endurance capacity (Chodzko-Zajko et al., 2009; Nelson et al., 2007). Several studies have investigated the relationship between increased strength or aerobic capacity and well-being or depression, but results are equivocal.

There are studies reporting that increased physical fitness is related to improved well-being (Mihalko & McAuley, 1996; Tsutsumi et al., 1998) or reduced depression (Baker et al., 2007; Penninx et al., 2002; Singh et al., 1997; Swoap et al., 1994). Some studies report improvements in well-being without improving physical fitness (Li et al., 2001; McAuley et al., 2000a; Oken et al., 2006). Others report physical improvements, but few or no relations to changes in well-being (Blumenthal et al., 1991; Cress et al., 1999; Emery & Gatz, 1990; Perrig-Chiello et al., 1998). Lastly, some report both physical and psychological changes, but they are not related (Emery & Blumenthal, 1990; Rejeski et al., 2001).

These ambiguous findings are also noted in reviews (McAuley & Rudolph, 1995; Netz, 2009; Rejeski et al., 1996; Rejeski & Mihalko, 2001), and meta-analyses (Arent et al., 2000; Netz et al., 2005). Netz and colleagues (2005) reported larger effects for studies reporting fitness improvements, while Arent and colleagues (2000) reported similar improvements. Hence, the validity of the fitness hypothesis has been questioned (Netz, 2009). The critique has been related to the fact that low intensity exercise or studies examining acute effects not improving fitness can have beneficial effects on well-being

(Li et al., 2002; McAuley et al., 2000b; Oken et al., 2006). Further, the studies have investigated changes in strength or aerobic capacity, but few have considered functional improvements, which may be more important for frail older adults (Manini & Pahor, 2009). Hence, the equivocal findings may be related to the type of improvement measured or the sample under investigation (Arent et al., 2000). However, the effects of physical improvements on well-being should be investigated, because the findings may guide how interventions are designed in the future (McAuley & Rudolph, 1995).

Psychological mediators

Due to equivocal findings around the effects of physical improvements on well-being in the elderly, it has been suggested that psychological mediators have a stronger impact on well-being (Fox, 2000; Netz, 2009).

The mastery hypothesis. One often-cited psychological explanation for why older adults feel better following exercise is the mastery hypothesis (Landers & Arent, 2007; McAuley & Rudolph, 1995; Netz et al., 2005). According to the mastery hypothesis, exercise may increase the subject's sense of control (e.g., competence or efficacy) through repeated mastery experiences and/or increased physical function, and these feelings in turn influence well-being. Due to multiple losses such as retirement and loss of friends and activities, aging can be related to loss of control, and the mastery hypothesis may be particularly applicable to older adults (Chodzko-Zajko et al., 2009; Daatland & Hansen, 2007; Heckhausen, 2005; Lang & Heckhausen, 2001; Langer & Rodin, 1976; Skinner, 1996).

The mastery hypothesis has its background in social-cognitive theory (Bandura, 1977; 1986) and control theories, where people are considered to have a motivation to

control their environment (Heckhausen, 2005; Lang & Heckhausen, 2001). Many psychological theories acknowledge the importance of feeling control over outcomes or one's environment and several constructs have been used to indicate feelings of mastery at different levels (e.g., self-efficacy, self-esteem, perceived competence, mastery; see Fox, 2000 or Skinner, 1996). Using the framework of social cognitive theory (Bandura, 1977; 1986), support is found for the mastery hypothesis among the elderly in the exercise domain. Correlational studies have related exercise self-efficacy to indices of well-being (McAuley et al., 2006; White et al., 2009). One longitudinal study found that the effect of increased exercise on subjective well-being was mediated by changes in self-efficacy and satisfaction with physical function (Rejeski et al., 2001). In a series of randomised trials, McAuley and colleagues have indicated that exercise increases self-efficacy in older adults (McAuley et al., 1999), and that these changes are related to change in well-being (McAuley et al., 2000b, 2005; Elavsky et al., 2005).

However, few studies have investigated the mastery hypothesis using constructs other than self-efficacy. In addition, different types of exercise may differentially influence feelings of mastery, but this is not confirmed in the literature.

Autonomy. Perceptions of choice, responsibility and autonomy can be important factors influencing an individual's sense of control and well-being (Fox, 2000; Kasser & Ryan, 1999; Langer & Rodin, 1976; Phillippe & Vallerand, 2008; Thompson & Wankel, 1980). Diary studies have related autonomy to well-being in younger populations (Reis et al., 2000; Sheldon et al., 1996). Aging may be related to a sense of lost autonomy. Therefore, one explanation that is closely related, albeit different, to the mastery

hypothesis is the degree of experiencing some personal responsibility and autonomy for one's own actions (Deci & Ryan, 1985a; Langer & Rodin, 1976; Skinner, 1996).

In an experimental study among older nursing home residents, Langer and Rodin (1976) showed that providing responsibility and freedom to make choices resulted in higher well-being, alertness and more active participation. Within exercise, Thompson and Wankel (1980) reported that a group given choice adhered more and reported higher intentions to continue with exercise compared to a control group in a 6 week programme. Further, Parfitt and Gledhill (2004) found that choice of mode influenced participant's positive affect and perceived exertion following a bout of exercise. Finally, among older adults in exercise, Arent and colleagues (2000) found the largest effects on well-being for trials where the duration of sessions was self-selected. Hence, participants' perceptions of autonomy seem relevant in influencing well-being in exercise. However, few exercise studies have actually measured perceptions of autonomy and tested the effect on well-being among the elderly.

The social-interaction hypothesis. Many psycho-social theories acknowledge the importance of social relations for a person's well-being (Baumeister & Leary, 1995; Deci & Ryan, 2000; Pinquart & Schindler, 2007; Steverink & Lindenberg, 2006). Older adults may experience a decrease in activities and social networks due to retirement or deaths of friends (Netz, 2009; Pinquart & Schindler, 2007). Because exercise is typically performed together with other participants or instructors, it is proposed that the social aspects of exercise are particularly important for older adults' feelings of well-being (McAuley et al., 2000a; Rejeski & Mihalko, 2001; Taylor et al., 2004).

Some studies have found that exercise class attendance is related to increased well-being (McAuley et al., 2000a, 2005) or reductions in depression (Baker et al., 2007). The authors hypothesised that the reason for the correlation was the higher frequency of social interactions. There are also more beneficial effects on well-being reported for exercising in a group environment compared to exercising alone (McAuley et al., 2000b). Similarly, a Norwegian study conducted on frail elderly subjects indicated larger effects on mental health for a group-based programme compared to a home-based programme (Helbostad et al., 2004). In contrast, there are reported positive well-being effects of home training (King et al., 2000, 2002). One study directly investigated the mediating effect of exercise-related social support on well-being; McAuley and colleagues (2000a) found that change in exercise frequency and social support was related to increase in life satisfaction during a 6 month trial among community-dwelling older adults. To sum up, there are too few studies directly investigating effects of social support on well-being and one can only suggest that social support through exercise improves well-being.

Moderating mechanisms

Moderators typically help us to understand for whom an intervention works (Kraemer et al., 2002), and can be classified as either characteristics of the person/group or characteristics of the exercise protocol.

Characteristics of the person/group

Initial physical and psychological health. Because physical health is closely related to older adults' well-being (Kunzmann et al., 2000; Ryff, 1989), the participants' initial physical health may influence the strength of an intervention's effect on well-

being. While it is likely that those with low physical health at commencement have more to gain from starting to exercise, results are equivocal. Netz and colleagues (2005) found larger effect size (ES) for interventions involving sedentary participants (ES = .35) compared to those involving active participants (ES = .17). Stigglebout and colleagues (2004) found beneficial effects on well-being only for participants with lower physical activity levels at commencement. In contrast, Arent and colleagues (2000) reported that exercise improved mood independent of participants' initial health status. Thus, exercise may be beneficial for all older adults' well-being, but it seems important to consider their initial physical health.

In addition, participants' psychological health (well-being) at commencement may affect the results. There is evidence of baseline value effects on change in well-being (Cress et al., 1999; Kelley et al., 2009; Mihalko & McAuley, 1996; Reed & Buck, 2009). Exercise studies involving depressed subjects (clinical samples) typically find larger effects (Craft & Landers, 1998; North et al., 1990) compared to studies involving non-clinical samples when investigating mental health outcomes (e.g., Arent et al., 2000; Netz et al., 2005). Hence, those with lower well-being at commencement may have more to gain following exercise (Blumenthal et al., 1989, 1991). Another reason for the beneficial effects found for those low in well-being may be ceiling effects on the scales used among participants initially high in well-being (e.g., Chin et al., 2004; DeVreede et al., 2007). One must also consider the phenomenon of regression to the mean, in that those low at the time of measuring well-being typically increase, while those high typically decrease. Thus, a control group must be present and the possible moderating effect of baseline well-being should be included in research.

Personality of participants. According to Diener and colleagues (Diener, 1984; Diener et al., 1999) peoples' personalities may affect their well-being in different situations or contexts. There seems to be some genetic influence on SWB (Lykken & Tellegen, 1996), but SWB may also vary between people and conditions. It has been found that personality traits like extraversion are related to positive affect and well-being and neuroticism has been related to negative affect (Costa & McCrae, 1980; Hillerås et al., 1998; Huppert, 2009; Jopp & Rott, 2006). For example an extravert could benefit more from a social exercise setting in terms of well-being compared to an introvert. Thus, a personality-environment interaction may be present, but few exercise trials have investigated this matter.

Valuing and/or enjoying exercise. Rejeski and Mihalko (2001) suggested that the effects of exercise on quality of life are larger for those who value or find the behaviour important. Others have also proposed that performing and having success in an activity one values results in enhanced well-being (Deci & Ryan, 2000; Oishi et al., 1999). One study among patients with knee osteoarthritis (mean age 71.8 years) found a moderating effect of importance placed on activities on the relationship between perceived difficulty and satisfaction with function (Rejeski et al., 1998). In addition, enjoyment has been reported as a strong indicator of activity level (Salmon et al., 2003) and important for adopting an exercise programme (King, 2001). An early cross-sectional study among retired men found that enjoyment moderated the effect of activity type on life satisfaction (Pepper, 1976). Exercise studies typically involve volunteers and there are few dropouts (Blumenthal et al., 1991; Oken et al., 2006). Hence, it may be that the trials are only working for those who value and enjoy exercise as a behaviour. No trials we are aware of

have assessed participants' value or enjoyment of exercise and its effects on well-being among community-dwelling older adults.

Leadership styles. Two experimental studies among young students, comparing an enriched leadership environment to a bland condition, have shown that the former is associated with higher revitalization, positive engagement, self-efficacy (Turner et al., 1997), and higher enjoyment and probability of future involvement in physical activity (Fox et al., 2000). Hence, the social environment as created by an instructor and participants' perceptions of the instructor may moderate the effect of a trial on well-being. However, it is not known what effect perceptions of the instructor have on the outcomes of exercise in the elderly (Turner et al., 1997).

Characteristics of the exercise protocol

Type of exercise. One important question in the literature has been whether some types of exercise influence participants' well-being more than others. Previous trials have often involved aerobic or strength training (Arent et al., 2000; Chodzko-Zajko et al., 2009; Kelley et al., 2009; Netz et al., 2005), but more recent trials have included other types of training such as power training (Henwood et al., 2008; Katula et al., 2008), functional training (Chin et al., 2004; DeVreede et al., 2007; Whitehurst et al., 2005), Tai-Chi (Li et al., 2001), yoga (Oken et al., 2006), and toning/stretching (McAuley et al., 1999, 2000a).

Meta-analyses report somewhat equivocal effects in relation to type of training; Arent and colleagues (2000) found the largest effects for mixed training (aerobic and strength, $ES = .49$), followed by strength training ($ES = .38$) and aerobic training ($ES = .26$). In contrast, Netz and colleagues (2005) found the largest effects for aerobic training

(ES = .29), followed by strength training (ES = .23), while the effects of combined training (calisthenics) were trivial (ES = .15). Although repeatedly requested, only a few trials have compared different training types. Penninx and colleagues (2002) compared the effects of aerobic and strength training and only the aerobic group showed reduced depression compared to the control group. Chin and colleagues (2004) reported decreased quality of life and vitality in a combined training group, while strength and functional training were similar to a social control group. DeVreede and colleagues (2007) reported an increase in perceived physical function in the strength group, compared to the control and functional group. Blumenthal and colleagues (1989, 1991) reported few or no substantial differences between aerobic training and yoga on indices of well-being. McAuley and colleagues (2000a) found positive effects in both a walking and a toning group on life satisfaction and self-efficacy. Hence, few clear differences between training types have been found in previous research, and there is no clear picture as to whether one type of training is more beneficial for older adults' well-being. One possible explanation is that there are different effects of training types on the different mechanisms and not the outcome. For example, functional types of training may be more beneficial for improving physical function, which in turn may affect well-being more than improved aerobic capacity or strength (Netz et al., 2005). Unfortunately, few studies have included functional types of training (Manini & Pahor, 2009). Further, feelings of mastery or social support might be more central affecting well-being in some activities. Therefore, type of activity should be investigated together with mediators.

Exercise dose (duration, intensity, time, frequency). Another question concerning the effect of different training protocols on well-being is the dose-response issue (Dunn et

al., 2005; Spirduso & Cronin, 2001). This reflects a physiological view-point in that longer duration, higher intensity, frequency and optimal training time should increase physical fitness more and thus facilitate well-being.

There may be an effect of the duration of a trial on the outcome. Both meta-analyses are consistent in this aspect and report the largest effects on well-being for shorter trials (Arent et al., 2000; Netz et al., 2005). In contrast, meta-analyses focusing on depression report more beneficial effects for longer trials (Craft & Landers, 1998; North et al., 1990). Therefore, the effect of duration of trials on mental health may depend upon the outcome under investigation. Some variables and also mechanisms may change rapidly (i.e., self-efficacy; McAuley et al., 2000b). Hence, multiple assessments of both the outcome and the mediators are needed during a trial (Kraemer et al., 2002). Unfortunately, most trials last between 8 and 24 weeks with only pre and post assessments, and only a few have included follow-up data.

Moderate intensity training is often proposed as adequate for older adults due to the chance of injury and the possibility of maintaining the level of activity for longer periods (Boileau et al., 1999; Cassilhas et al., 2007; Nelson et al., 2007; Swoap et al., 1994; Tsutsumi et al., 1998). The previously mentioned meta-analyses both found largest effects for moderate intensity (Arent et al., 2000; Netz et al., 2005), but other studies have found high intensity (Tsutsumi et al., 1998; Cassilhas et al., 2007) and low intensity training such as Tai-Chi (Li et al., 2001), yoga (Oken et al., 2006) and toning/stretching (McAuley et al., 2000a) to be beneficial. These findings indicate that high intensity activity may not be necessary to achieve well-being benefits among older adults, and results are in contrast to those for younger participants where low intensity did not

influence affect (Arent et al., 2005). A few studies that have compared high and moderate intensities report few differences, but recommend moderate intensity because of similar physical improvements (Cassilhas et al., 2007; Swoap et al., 1994; Tsutsumi et al., 1998).

When it comes to frequency of sessions per week the results are also inconsistent. Netz and colleagues (2005) reported a positive but non-significant effect of exercise frequency, while Arent and colleagues (2000) reported the largest effects in trials with <3 session per week (ES = .69) compared to trials with ≥ 3 sessions per week (ES= .28). Most trials involve 3 training sessions per week (Cassilhas et al., 2007; Cress et al., 1999; DeVreede et al., 2007; Katula et al., 2008; McAuley et al., 1999, 2000a; Mihalko & Rudolph, 1996; Tsutsumi et al., 1998). However, there are reported beneficial well-being effects among healthy older adults with low activity level at baseline with two sessions per week (Stiggelbout et al., 2004). Thus the sample under investigation, the training dose and how the trial is designed may influence the results.

Psychological framework

Due to the inconsistent research results, more theoretically-driven research has been called for when investigating the effects of exercise on well-being among older adults (Biddle & Nigg, 2000; Buckworth & Dishman, 2002; Marcus et al., 2006; Rejeski et al., 1996; Standage & Duda, 2004). A psychological theory may define relevant mediators and moderators of the exercise–well-being relation, and the present study aimed to identify and test possible mechanisms suggested by self-determination theory (SDT; Deci & Ryan, 1985a, 2000; Ryan & Deci, 2000, 2002). This chapter is devoted to the psychological framework employed in Papers II-IV.

Self-Determination Theory

Self-determination theory is a growth-oriented personality and social psychological theory especially concerned with peoples' development, motivation and well-being (Deci & Ryan, 2000; Ryan & Deci, 2000). One basic assumption in SDT is that people are naturally oriented towards positive development and health. For this growth process to occur, three basic psychological needs for autonomy, competence and relatedness must be fulfilled (Deci & Ryan, 2000; Ryan & Deci, 2002). *Autonomy* refers to the feeling of being the causal agent of one's behaviour, to experience volition and to act in accordance with personal values. *Competence* refers to people's need to feel a sense of mastery and being effective in dealing with the environment. *Relatedness* concerns the feeling of being meaningfully connected to, being cared for and having a sense of belongingness with other individuals (Deci & Ryan, 2000; Deci & Vansteenkiste, 2004; Ryan & Deci, 2002). When these needs are fulfilled people should demonstrate high motivational quality and well-being, but if the needs are thwarted people do not function optimally and ill-being and dysfunction may occur. Thus, the needs provide information about the social conditions that demonstrate well-being (Deci & Ryan, 2000; Deci & Vansteenkiste, 2004; Ryan & Deci, 2002).

Another central concept in SDT is regulation of motivation. First, SDT suggests three types of motivation; intrinsic, extrinsic and amotivation (Deci & Ryan, 2000; Standage & Duda, 2004). Intrinsic motivation refers to "doing an activity for the satisfaction of the activity itself" (Ryan & Deci, 2000, p. 71) and is considered the prototype of self-determination influencing the positive tendency towards growth in humans (Deci & Ryan, 1991; Ryan & Deci, 2000). In contrast, extrinsic motivation refers

to “doing a behaviour to attain a separable outcome” (Ryan & Deci, 2000, p. 71), while amotivation is “a state where people lack motivation to act” (Deci & Ryan, 2000, p. 237). Further, SDT has a differentiated view of extrinsic motivation because people can be motivated to act for several other reasons. Thus, four types of extrinsic motivation lying along a continuum ranging from self-determined to non-self-determined are suggested (see Figure 1). The differences in degree of self-determination are considered to differentially influence people’s behaviour and the outcomes of performing the behaviour (Ryan & Connel, 1989; Ryan & Deci, 2002).

Integrated regulation is the most self-determined type of extrinsic motivation, where the regulation is accepted as one’s own and brought into coherence with other values and needs (Deci & Ryan, 2000)¹. Next on the continuum is *identified regulation*, where people accept and find the value of the behaviour personally important. A less self-determined type of regulation is *introjection* in which the behaviour is typically guided by guilt, anxiety or to maintain feelings of self-worth. Introjection is considered a controlled state where the regulation is internal, but not accepted as one’s own. The least self-determined form of motivation is *external regulation*, which is similar to the classical extrinsic motivation, characterised by acting to attain a reward, please others or avoid punishment (Deci & Ryan, 2000; Ryan & Deci, 2000). Because self-determined extrinsic forms of motivation can have positive consequences, researchers often differentiate between autonomous (intrinsic, integrated and identified) and controlled

¹ Integrated regulation is similar to intrinsic motivation, but is still considered extrinsic because it is performed for a separable outcome (Ryan & Deci, 2000). Integration has rarely been measured in research due the difficulty of empirically distinguishing it from intrinsic and identified regulations (Mullan et al., 1997; Teixeira et al., 2012). Recently, scales including integrated regulation have shown promise when evaluating divergent validity (Münster-Halvari et al., 2010; Li, 1999).

(external and introjected) forms of regulation (Deci & Ryan, 2000; Fortiér et al., 2007; Williams et al., 2004, 2006).

Behaviour	Non-self-determined				Self-determined	
Type of Motivation	Amotivation	Extrinsic Motivation				Intrinsic Motivation
Type of Regulation	Non-regulation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation
Locus of Causality	Impersonal	External	Somewhat External	Somewhat Internal	Internal	Internal

Figure 1. The self-determination continuum (retrieved from Deci & Ryan, 2000, p. 237).

In addition to need satisfaction and motivation, people's perceptions of competence have been shown to influence their behaviour and well-being. People perceive themselves as competent when they feel able to control and attain important outcomes (Williams et al., 2004, p. 58). In that way, perceived competence, like the concept of self-efficacy, is related to peoples' capability to act and perform well (Bandura, 1986; Williams et al., 2006). Several studies involving the SDT process model of health behaviour have shown that perceptions of competence and autonomous motivation are related to positive health behaviours such as glycemic control (Williams et al., 2004), tobacco cessation (Williams et al., 2006), dental care (Münster-Halvari et al., 2006), and indices of well-being (Williams et al., 2007; 2009).

One important feature of SDT is how people move up or down the continuum (i.e., become more or less self-determined) when performing a behaviour. This is the process of internalisation, whereby people assimilate the values and regulations of the

environment into their own value systems. According to Deci and Ryan (1991, 2000) people will internalise a more self-determined form of motivation when the three needs for autonomy, competence and relatedness are satisfied. Early research revealed that environmental factors like deadlines, rewards, choice and feedback affected peoples' intrinsic motivation to the degree they were perceived as satisfying or thwarting their needs (Deci & Ryan, 1985a, 2000). Therefore, the social environment becomes central in regulating an individual's behaviour, and much attention is given to whether important others support people's autonomy, relatedness and competence (Gagné et al., 2003; Mageau & Vallerand, 2003; Williams et al., 1996). This can be done through autonomy support characterised by "an environment where a significant other offers choice, provides a rationale for the behaviour, minimises pressure and acknowledges the person's feelings" (Williams et al., 1996, p. 117)².

Finally³, in addition to the social context, SDT holds that people have dispositional differences that are important to consider in understanding how they interpret the environment or situation, their perception of need satisfaction and again, their regulation of motivation (Deci & Ryan, 1985b; Rose et al., 2001, 2005). These dispositions are named causality orientations, and are considered relatively stable internal characteristics developed through previous experiences with the social context (Deci & Ryan, 2000). Three different orientations are proposed: an autonomously orientated

² Several concepts have been used for a supportive environment (autonomy support, involvement, structure, need support (Reeve, 2002; Teixeira et al., 2012), but the dimensions are often collapsed into the concept of autonomy support (Markland & Tobin, 2010). The environmental dimensions may differ, but the definition and measure of autonomy support provided by Williams and colleagues (1996) includes support of all three needs. Thus, the term autonomy support is used in the present study when describing a milieu supporting the needs of the individual.

³ SDT also acknowledge that people's motives, named goal content, influence their behaviour and well-being. This aspect of SDT is not considered here because it is not under investigation in the present study, but interested readers are referred to Deci and Ryan, 2000.

person generally acts on the basis of interests and self-endorsed values; a control oriented individual has a tendency to behave by following controls and directives from others; and an impersonally orientated individual is more passive, focuses on indicators of inefficacy and does not behave intentionally (Deci & Ryan, 1985b, 2000).

The key concepts of SDT have often been investigated separately and are generally supported in the available research. A positive relationship between an autonomy supportive environment and more self-determined motivation has been found (Black & Deci, 2000; Deci et al., 1994; Grolnick & Ryan, 1989; Pelletier et al., 2001). Need satisfaction has been related to regulation of motivation (Gagné et al., 2003; Markland & Tobin, 2010; Puente & Anshel, 2010; Wilson & Rodgers, 2008) or directly linked to feelings of well-being (Reis et al., 2000; Sheldon et al., 1996). Others have found that motivation, either controlled or autonomous, differentially affects well-being (Nix et al., 1999; Ryan & Frederick, 1993). In terms of causality orientations, autonomous orientation has been related to autonomous motivation (Rose et al., 2001, 2005; Williams et al., 1996) and indicators of well-being (Deci & Ryan, 1985b; Knee & Zuckerman, 1998; Kwan et al., 2011). The “Basic Need Theory” (BNT; Deci & Ryan, 2000) describes the interplay between the social environment (e.g., autonomy support), need satisfaction, motivation (degree of self-determination) and well-being. In short, perceptions of autonomy support influence perceived need satisfaction, which in turn influences regulation of motivation, perceptions of competence, and well-being. Hence, both the needs and regulation of motivation are considered mediators between perceptions of the environment and outcomes.

Research on older adults within SDT

Although research within SDT has expanded greatly in various domains, only a few studies involve older subjects (Ryan & LaGuardia, 2000; Standage & Duda, 2004). Cross-sectional studies have related autonomous types of motivation positively to life satisfaction, meaning in life, self-esteem and subjective health, and negatively to depression, while the opposite pattern has occurred for controlled motivation (Vallerand & O'Connor, 1989; Vallerand et al., 1995). In relation to need satisfaction, autonomy has been linked to life satisfaction among nursing home residents (Vallerand et al., 1989). O'Connor and Vallerand (1994) indicated that the relation between autonomy support and autonomous motivation was mediated by perceptions of freedom and choice (autonomy). Kasser and Ryan (1999) included indicators of relatedness and found that autonomy support from staff and friends was positively related to well-being, and negatively related to depression. Further, the number of social contacts was positively related to vitality, quality of relatedness to friends was positively related to general well-being, and autonomous motivation was positively related to vitality and negatively to mortality one year later (Kasser & Ryan, 1999). In one study of elderly subjects that can be linked to physical activity it was found that opportunities for leisure activities were positively related to autonomous motivation, while leisure constraints were negatively related. Autonomous motivation again predicted leisure satisfaction and participation (Losier et al., 1993).

Three prospective studies have been conducted with older subjects. Phillippe and Vallerand (2008) obtained data from O'Connor and Vallerand (1994), and reported that perceptions of autonomy support and autonomy predicted self-determined motivation and psychological well-being a year later. Autonomous motivation mediated the relationship

between perceived autonomy and well-being. Two one-year studies among patients with diabetes (mean age 64 years) found that change in perceived competence partially mediated the effect of autonomy support on diabetic distress and depression (Williams et al., 2007), and that autonomy support was related to autonomous motivation, which was related to perceived competence, which again was related to well-being and medical adherence (Williams et al., 2009).

Self-determination theory within the exercise domain

There has been much research on SDT's predictions within the exercise domain over the last decade (for an overview, see Hagger & Chatzisarantis, 2007; Ryan et al., 2009; Teixeira et al., 2012; Wilson et al., 2008). Due to the diversity in research and the aim of this dissertation, the focus will be on studies involving the key constructs and their relationship to well-being outcomes in exercise.

Causality orientations in exercise. Within the exercise domain, cross-sectional studies support the relationship between causality orientations and motivational regulation as predicted by Deci and Ryan (1985a, 1985b). Autonomous orientation has been positively related to autonomous regulation and introjection, and negatively to external regulation. Controlled orientation has been positively related to introjection and external regulation. Impersonal orientation has been negatively related to autonomous regulation and introjection and positively to external regulation (Rose et al., 2001, 2005).

In relation to well-being indices, Rose and colleagues (2001) found no significant correlation between orientation and social anxiety. One recent 4-week diary study found that affective responses partly mediated the relationship between baseline autonomy and impersonal orientations and motivational regulation at follow-up (Kwan et al., 2011).

According to SDT, causality orientations may interact with the context and situation in explaining behavioural outcomes (Deci & Ryan, 1985; Rose et al., 2005). Similarly, Diener and colleagues (1999) suggest that an environment-personality interaction affects people's subjective well-being. Thus, causality orientations may directly influence change in motivation and well-being following exercise, or there may be an interaction between exercise and orientations that explains changes in well-being. However, very few exercise studies have included causality orientations and there is a need to know more about the effect of causality orientations on motivational variables and well-being (Rose et al., 2005 Ryan & Deci, 2007; Teixeira et al., 2012)

Autonomy support, need satisfaction and well-being in exercise. The positive relationship between need satisfaction in exercise and indices of well-being has been supported in cross-sectional studies (Vlachopoulos & Karavani, 2009; Wilson et al., 2006a, 2009). There is also a partial mediating effect of need satisfaction between perceived autonomy support and vitality (Adie et al., 2008; Vlachopoulos & Karavani, 2009). In a small experimental study, Vazou-Ekkekakis and Ekkekakis (2009) found lower intrinsic motivation and energy as a function of decreased perceptions of autonomy in an exercise bout. Longitudinal studies also support SDT; one prospective study among university students and staff found that need satisfaction was positively related to well-being and negatively related to psychological distress 8 weeks later (Wilson et al., 2009). Wilson and colleagues (2006a) found that change in autonomy and relatedness was related to change in vitality in a 12-week resistance programme among females. Edmunds and colleagues (2007a) found that change in autonomy was a positive predictor of change in life satisfaction among obese individuals. Edmunds and colleagues (2008)

performed a 10 week exercise programme where participants were designated into either an SDT class (an autonomy supportive, well-structured and involvement-oriented teaching style) or a control class (standard exercise environment). The SDT class showed increases in relatedness, autonomy, positive affect and they attended more classes than the controls. There was no difference in change in motivational regulation between the groups. Further, the effect of autonomy support on intrinsic and identified regulation increased over time. The need for competence was negatively related to negative affect, while external regulation and amotivation were positively related.

Motivation and well-being in exercise. Cross-sectional studies have supported the positive relationship between exercise, autonomous motivation and indices of well-being such as satisfaction with activity (Ryan & Frederick, 1993), physical self-worth (Thøgersen-Ntoumani & Ntoumanis, 2006) and positive and negative affect (Puente & Anshel, 2010). In contrast, controlled motivation has been related to lower self-esteem and anxiety (Frederick & Ryan, 1993), and social physique anxiety (Thøgersen-Ntoumani & Ntoumanis, 2006). Puente and Anshel (2010) also found that perceptions of competence and autonomy mediated the relationship between instructors' autonomy support and self-determined motivation, and that self-determined motivation partially mediated the effect of perceived competence and autonomy on positive affect, negative affect, enjoyment and exercise frequency.

The cited studies are limited by their cross-sectional design, but two longitudinal exercise studies reported a positive relationship between autonomous motivation and well-being. Wilson and Rodgers (2002) found that baseline intrinsic and identified regulation for exercise was positively, and introjection was negatively, related to

perceptions of physical self-esteem among females 10 weeks later. In a 3-month study, Edmunds and colleagues (2007a) found that change in intrinsic motivation predicted change in positive affect, while change in introjection negatively predicted change in vitality.

The present study

As stated previously, there is a need to identify relevant mediators and moderators in exercise among older adults with substantial effects on well-being. When such variables are identified we can create more effective training interventions and environments in the future (Biddle & Nigg, 2000; King et al., 1998; Marcus et al., 2006; Rejeski & Mihalko, 2001; Standage & Duda, 2004). Further, such research should be theory-based, because a psychological theory can define the relevant variables and provide information on how to manipulate them (Hagger & Chatzisarantis, 2008; Standage & Duda, 2004). Many of the variables suggested by SDT as influencing well-being can be related to the mechanisms proposed in the general exercise literature among older adults. With that in mind, it is surprising that no study had included SDT as a framework when investigating the effects of exercise on well-being among older adults (Standage & Duda, 2004; Wilson et al., 2006a). Older adults are particularly at risk for reductions in autonomy, competence and relatedness due to multiple losses such as decreased physical capacity, retirement, and death of friends. They may have fewer opportunities to perform at the highest intellectual and physiological level (Chodzko-Zajko et al., 2009; Heckhausen, 2005; Vallerand et al., 1989). The need for competence and perceived competence can be related to the mastery hypothesis. Perceived choice is considered an important aspect of feelings of control and autonomy (Deci & Ryan, 1985;

Langer & Rodin, 1976; Parfitt & Gledhill, 2004), and the social interaction hypothesis can be investigated through perceptions of autonomy support from instructors and relatedness to the other participants in the exercise group.

Further, other studies have suggested that enjoyment and value can be both determinants of exercise and moderators or mediators of its outcomes (Elavsky et al., 2005; Rejeski & Mihalko, 2001; Rejeski et al., 1998). Indeed, SDT provides a framework for investigating the effects of enjoyment and value on well-being among participants through the concept of motivational regulation: enjoyment is a central characteristic of intrinsic motivation (Deci & Ryan, 1985a; Ryan & Deci, 2000), while identified regulation is defined as valuing a behaviour and finding it important. The importance of value and enjoyment has also been indicated in SDT based studies; autonomous motivation can be a mediator of the exercise–well-being relationship (Edmunds et al., 2007a; Fortier et al., 2007), and also a moderator (Pelletier et al., 2001; Wilson & Rodgers, 2002). In terms of effects of personality on well-being in exercise, SDT also contains individual differences, named causality orientations.

The results from SDT-based studies in the exercise domain and among older adults are generally in accordance with Deci and Ryan's (2000) predictions in that autonomous regulation is a consequence of a supporting environment and people's perceptions of need satisfaction. Need satisfaction and motivational regulations have in turn been related to people's well-being in exercise. However, there are several shortcomings. First, previous SDT-based exercise studies have involved young, predominantly active subjects (Thøgersen-Ntoumani & Ntoumanis, 2006; Wilson et al., 2009; Wilson & Rodgers, 2004, 2008) or students (Edmunds et al., 2008; Wilson &

Rodgers, 2002). Hence, little is known about the elderly within the exercise domain although information is frequently requested by researchers (Adie et al., 2008; Edmunds et al., 2007b; Standage & Duda, 2004; Vlachopoulos & Karavani, 2009). Second, the few SDT-based studies that do involve older subjects have included nursing home residents although most older adults are community-dwelling (e.g., Kasser & Ryan, 1999; O'Connor & Vallerand, 1994; Phillippe & Vallerand, 2008; Vallerand et al., 1989, 1995). Third, there is a lack of longitudinal and experimental data, and no study has investigated whether different types of exercise differentially affect participants' need satisfaction (Vlachopoulos & Karavani, 2009; Wilson & Rodgers, 2002, Wilson et al., 2009). Fourth, few studies have investigated relations between motivation and well-being indices compared to exercise behaviour (Teixeira et al., 2012; Wilson & Rodgers, 2007). Until now, no study has investigated the effects of older adults motivational regulation for exercise on well-being. Consequently, the present study aimed to include SDT as a framework when testing possible mechanisms helping to explain well-being outcomes of exercise, and also to extend current knowledge within SDT to older adults in exercise.

Figure 2 presents an overview of the theoretical model, and the relationships between variables as suggested by SDT (Deci & Ryan, 2000). Solid lines indicate relations tested in this study.

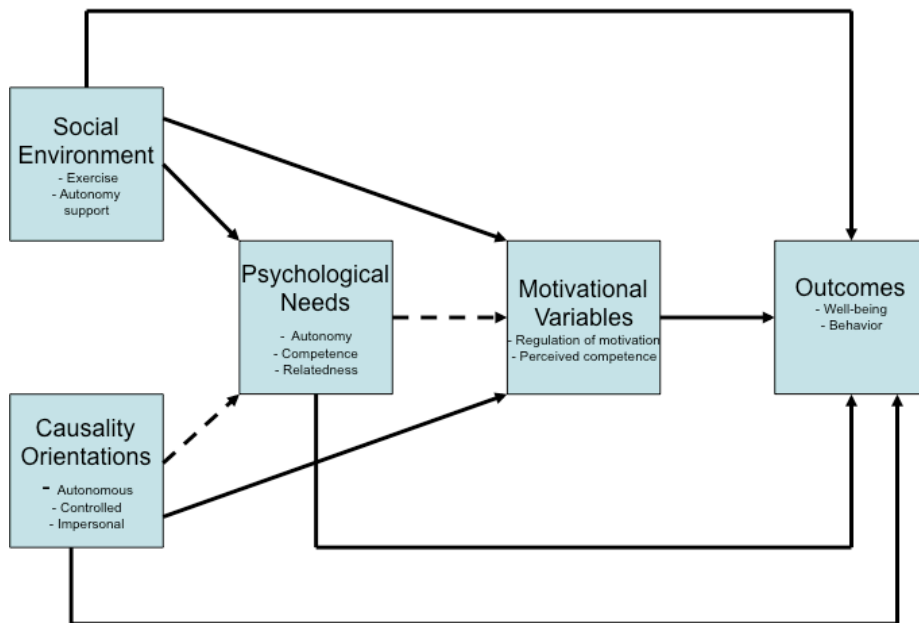


Figure 2. The theoretical model (modified from Deci & Ryan, 2000)

RESEARCH QUESTIONS

Research question 1:

What are the effects of three different types of exercise on well-being in older adults?

Research question 2:

Do the social-contextual and motivational variables suggested by self-determination theory (SDT) mediate and/or moderate the relations between exercise and well-being in older adults?

METHODS

Study design

The present study was a single-blinded, parallel-group, randomised controlled exercise trial with four groups and measurements at baseline, week 7, week 16 and a follow-up 12 months after cessation. Advertisements in local newspapers and posters in the area around the Norwegian School of Sport Sciences (Northern Oslo) invited men and women ≥ 70 years, who did not exercise regularly, to take part in an exercise study free of charge and assisted by professional instructors. The training sessions took place over three consecutive time periods (August to December, 2008, January to May, 2009 and August to December, 2009). Hence, during the second and third training periods some participants were recruited through word of mouth and “snowballing effects”.

Inclusion criteria were: age ≥ 70 years, home living, sedentary (defined as a maximum of one organised and structured exercise session per week during the past 6 months), and being able to read and speak Norwegian. Exclusion criteria were: myocardial infarction during the previous six months, uncontrolled hypertension, bone mineral density in L2-L4 $< 0.84 \text{ g.cm}^{-2}$ (assessed by DXA bone scan), use of corticosteroids during the previous six months, and cognitive impairment (< 24 on the Mini Mental State Examination, MMSE; Folstein et al., 1975). To ensure that the exercise or testing did not cause any harm to participants, two medical doctors with thorough knowledge of the training intervention carried out medical screenings at the intervention site.

Participants

The recruitment procedures resulted in return phone calls and emails from 284 potential participants. One hundred and twenty three respondents were found ineligible or withdrew from further participation after a telephone interview or informational meeting. Twelve participants were excluded after medical screenings, and another 11 withdrew from the study before the physical tests. The main reasons for exclusions or withdrawals were: age (<70 years), time commitment, or they were already involved in structured exercise programmes. The remaining 138 participants ($M = 74.2$, $SD = 4.5$ years; 68% females) were allocated to one of four treatments: traditional strength training, functional strength training, endurance training, and wait-list control (see Figure 3 for full details on recruitment and retention of participants throughout the study).

Randomization procedures

Because participants are non-blinded in exercise studies, the randomization was performed after baseline assessments. To minimise differences between the groups, the randomization was stratified on gender and mean baseline scores on six tests of physical function (stair climb, chair rise, timed up and go, maximal walk speed, functional upper body strength test and 6-minute walk test). Seven couples were allocated as one person to minimise differences between groups. Participants were randomised by the researchers carrying out the trial (P. A. Solberg and N. H. Kvamme). The researchers only had the participant's physical test-scores and id-number available and were not involved in any physical testing.

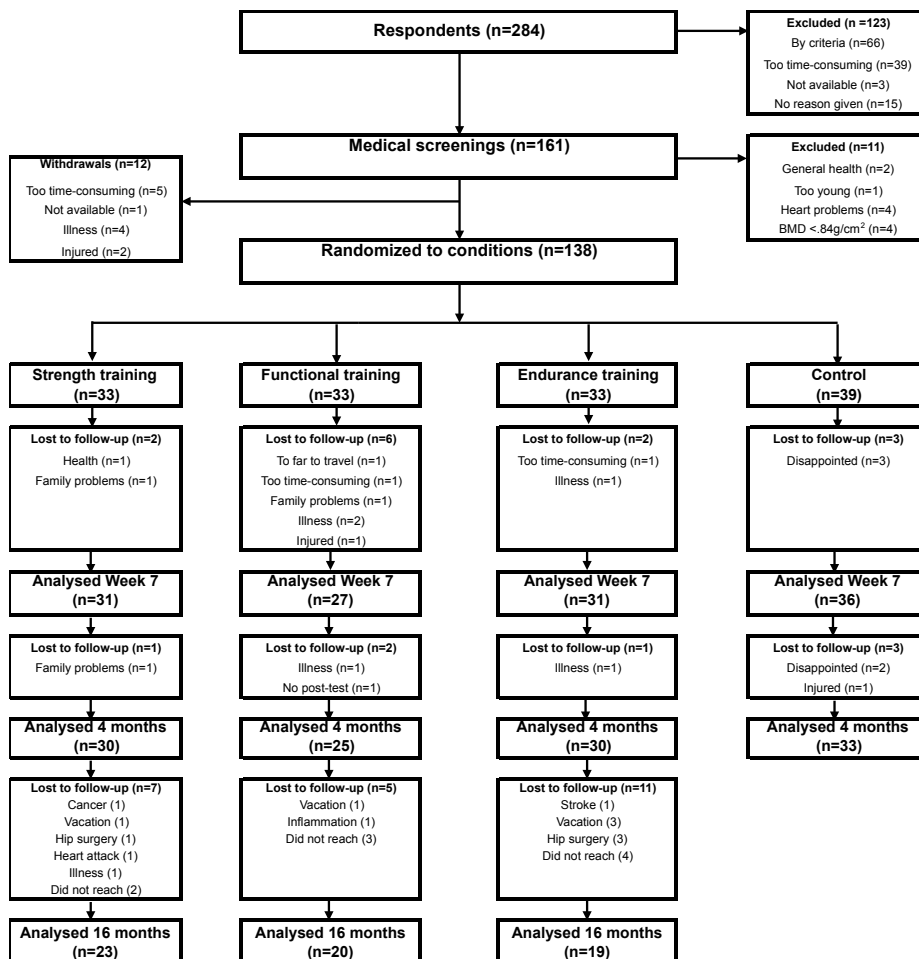


Figure 3. Recruitment and retention of participants throughout the study

Ethics

All participants provided written informed consent prior to the trial, and they were given a code number to ensure anonymity throughout the study. The study was approved

by the Regional Ethics Committee of Southern Norway and the Norwegian Social Science Data Services (Appendix A).

Other practical and ethical considerations were: a) all participants were offered travel-passes for the subway, or a corresponding amount was offered to those who drove their own vehicle, b) seven couples were randomised as one person to comply with their wish and to ease their burden in terms of travelling, c) the exercise periods and tests were performed in three cycles in order to recruit the necessary sample size, but also to ensure proper follow-up of each subject during training by having smaller groups, d) to avoid dropouts, participants allocated to the wait-list control group were offered a similar training as the exercise groups after the control period, e) participants in the endurance group were given crampons to use when walking during winter time, f) elderly often have several clinical conditions (Christensen et al., 2009; Nelson et al., 2007) and we opted for involving as many as possible in order to reflect the population in general. Thus, people with controlled diabetes and hypertension were included.

Intervention groups

The exercise groups performed three sessions per week for 13 weeks. Each training session lasted approximately 60 minutes, including a 10 min warm up and a 10 min cool down.

Strength training group (STG, n=33). The STG performed one to three sets of traditional heavy strength training consisting of 8 exercises involving all major muscle groups. The strength training protocol was a mix between linear periodization and daily undulating periodization. Participants started with 8-12 RM (repetition maximum) sets, and ended with 4-8 RM sets (For more details see Paper I, p. 116). Before each session

the participants warmed up for 10-15 min on treadmill, bicycle, step machine or rowing machine. The participants exercised in groups of two to four and to ensure safety and quality in the exercise all sessions were supervised by a qualified instructor. Perceived exertion (RPE; Borg, 1982) was not assessed because this is by definition a high-intensity protocol.

Functional strength training group (FTG, n = 33). The participants in FTG performed loaded exercises (12-15 RM) that mimicked activities of daily living in two high intensity and one medium intensity sessions per week. Training was performed as circuit training and the exercises were loaded using weight vests, dumbbells and sandbags (For more details see Paper I, p. 117). All participants registered the load for each exercise on a form, and were encouraged to gradually increase their load throughout the training period. Two instructors were always present for each group of 12 to 15 participants. Mean RPE was 14.5 ± 0.9 on the 6-20 Borg scale and in the range between moderate and vigorous intensity (Borg, 1982).

Endurance training group (ETG, n = 33). Participants in the ETG performed Nordic Walking, aerobics to music, and hiking in rugged terrain on three different days each week (For more details see Paper 1, p. 117). Two instructors supervised all sessions. RPE was moderate (Borg, 1982) with ratings of 13.3 ± 2.4 for Nordic Walking, 14.2 ± 2.4 for aerobics, and 12.8 ± 2.1 for hiking.

Wait-list control group (CON, n = 39). Participants in the control group were inquired to continue their daily activities as before, and to not start any new training programmes while on the wait-list.

Procedures and Time Line

The total duration of the intervention was 16 weeks, including 1 week to familiarise the subjects to the tests and exercises, 1 week of pre-testing, 13 weeks of training and 1 week of post-testing. A follow-up was performed 12 months after cessation (Figure 4).

Baseline assessments (T0). Baseline testing occurred over two weeks. First, to ensure that participants' responses were not influenced by the challenges of the physical pre-tests, baseline questionnaires were completed the first time participants came for familiarization to testing at the intervention site. Physical tests were performed in week 2 (after two familiarization sessions) on two different days, with at least one day's rest between. Some of the exercise-specific psychometric scales (i.e., need satisfaction and causality orientations) were measured in week 2, after the familiarization and physical testing (e.g., McAuley et al., 2000a).

Week 7-assessments (T1). During week 7 of the intervention (after 4 weeks of training) all participants completed assessments of motivation, perceived competence and well-being. In addition, participants in the exercise groups completed perceptions of need satisfaction and autonomy support from instructors. Questionnaires were mailed to the control group. The controls had no interaction with instructors or other participants, and did not complete perceived need satisfaction and autonomy support questionnaires. No physical tests were performed at week 7.

Post-assessments (T2; 16 weeks, 4 months). All participants, including controls, completed the questionnaires and physical tests at the intervention site 16 weeks after baseline (3 to 5 days after the 13-week training period). The small delay was included in

order to give participants time to recover after the exercise intervention. Psychological measures were again completed before physical tests to ensure that participants' results and experiences did not influence their responses. Participants in the three exercise groups also rated perceptions of need satisfaction and autonomy support from instructors.

Follow-up assessments (T3; 16 months). One year after cessation of the intervention, participants in the three exercise groups were contacted for follow-up measurements of physical activity level and well-being. Because controls were offered training similar to the exercise groups after the wait-list period, there were no proper controls available at follow-up (Figure 3).

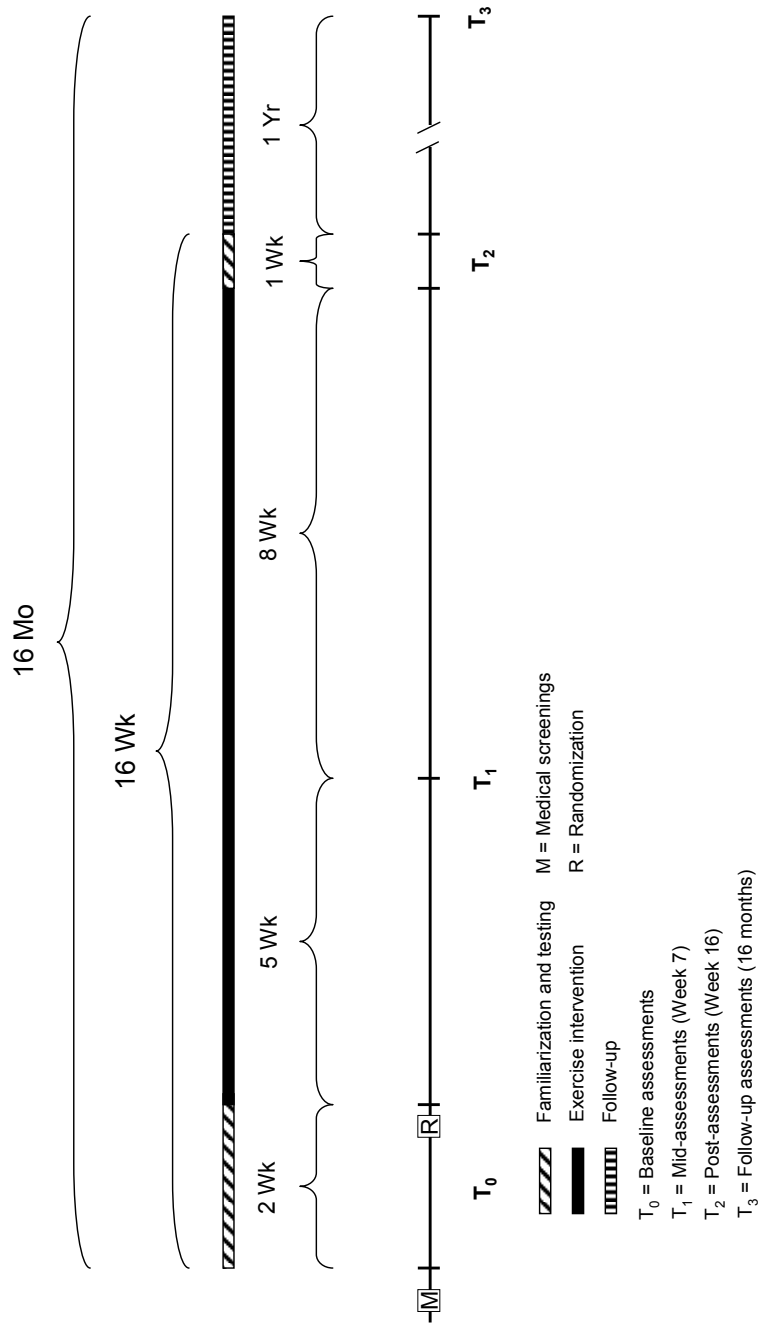


Figure 4. Timeline of the intervention

Measures

The psychological measures are described in their respective papers and listed in Table 1. All scales, except the causality orientations, had acceptable reliability with alpha values $>.70$. The original versions of all scales are also included in Appendix C.

Demographic variables. Participants' age, marital status, living status, level of education, occupational status, use of tobacco and alcohol and self-rated health (one item from the SF-36; Ware & Sherbourne, 1992) were assessed at baseline. Paper I includes the demographics, activity level, prevalent diseases, strength (1 RM), functional performance and body composition for those completing week 16 ($n = 118$). Paper II includes demographics of the subjects analysed at week 7 ($n = 125$) and the dropouts at week 16 ($n = 20$). In Paper IV the subjects completing follow-up measurements ($n = 62$) and those lost to follow-up ($n = 37$) are described.

Table 1. Overview of scales used in the study

Measures	Scale	Validated	Paper
<u>Outcome variables</u>			
Life satisfaction	SWLS; Pavot & Diener, 1993	Pavot & Diener, 1993	1,3,4
Positive affect	PANAS; Watson et al., 1988	Kercher, 1998; Hillerås et al., 1998	1,3,4
Negative affect	PANAS; Watson et al., 1988	Kercher, 1998; Hillerås et al., 1998	1,3,4
Vitality	SVS; Ryan & Frederick, 1997	Bostic et al., 2000	2,3,4
Frequency of physical activity	SSB, 2009		4
<u>Mediators</u>			
Need satisfaction	BPNES; Vlachopoulos & Michailidou, 2006	Vlachopoulos & Michailidou, 2006	2
Motivation	BREQ; Mullan et al., 1997	Wilson et al., 2002	3
Perceived competence	PCS; Williams & Deci, 1996	Fortiér et al., 2007	3
<u>Moderators</u>			
Autonomy support	HCCQ; Williams et al., 1996		2
Causality orientations	GCOS; Deci & Ryan, 1985	ECOS; Rose et al., 2001	3
Baseline motivation	BREQ; Mullan et al., 1997	Mullan et al., 1997; Wilson et al., 2002	4

Note. For a more detailed description of the scales see the respective papers.

Selection, translation and pilot testing of scales

Selection. All scales were selected based on previous exercise research among older adults and research conducted within self-determination theory. “The Satisfaction With Life Scale (SWLS; Pavot & Diener, 1993), “the Positive and Negative affect Schedule” (PANAS; Watson et al., 1988) and “the Subjective Vitality Scale” (SVS; Ryan & Frederick, 1997) were available in Norwegian, and three to four versions were compared (the Norwegian Life Course Ageing and Generation study; NorLAG, 2006; Pensgaard & Duda, 2003; Solberg & Halvari, 2009; Strandkleiv, 1999). Three researchers discussed each item and agreed on which version to use. The NorLAG versions of SWLS and PANAS were adopted because data from 1150 older adults in Norway were available.

Translation. Four SDT-based scales were not available in Norwegian: “the Behavioural Regulation in Exercise Questionnaire (BREQ; Mullan et al., 1997), “the General Causality Orientations Scale (GCOS; Deci & Ryan, 1985b), “the Exercise Causality Orientations Scale (ECOS; Rose et al., 2001), and “the Basic Psychological Needs in Exercise Scale” (BPNES; Vlachopoulos & Michailidou, 2006). Hence, these scales were translated and adapted following the procedures suggested by Beaton and colleagues (2000): First, three researchers familiar with SDT translated the scales to Norwegian and agreed on a common Norwegian version. Secondly, this version was back-translated to English by two independent persons (one English teacher and one researcher in general psychology). Thirdly, the two versions were compared with the original to ensure that the items reflected the same content.

Pilot. A pilot test of some questionnaires was conducted on 57 older adults ($M = 73.4$ years, $SD = 6.5$ years, range 62-90 years, 68.4% females). Among these, 45 were

following a group exercise programme at the intervention site and 12 were recruited from a fitness center.

The 15-item BREQ (Mullan et al., 1997) was tested along with two identified and introjected items from “the treatment self-regulation questionnaire (TSRQ; Williams et al., 1996). The reason for including four extra items in the pilot was because the BREQ only has three introjected items, and this subscale had previously shown borderline low alpha reliability ($\alpha = .67$, Wilson et al., 2003). In addition, one previous study indicated low alpha reliability on the identified subscale in BREQ (Wilson & Rodgers, 2008). It was important to have a strong identified subscale because identification may be especially essential in regulating valuable “uninteresting” activities like exercise (Edmunds et al., 2007a; Wilson et al., 2008).

Some small adjustments were done to the BREQ after the pilot test. First, the stem was modified from “Why do you exercise” to “Why do you want to exercise?” In addition, the word “regularly” was deleted from the identified items. These two changes made the scale more suitable for the sedentary participants. Secondly, one of the identified items loaded on introjection in the factor analyses (“I get restless if I don’t exercise regularly”). Considering the definition of introjection as described (Deci & Ryan, 2000), the content of this item may be more introjected. It is possible that the word “regularly” which is used in the original version made the items load on the same factor in the creation of BREQ (Mullan et al., 1997). Markland and Tobin (2004) omitted this item in the validation of BREQ-2. The item was therefore replaced with one identified item from TSRQ (“It is personally important to me”). Thirdly, to have four items and ensure high reliability in the introjection subscale, one item from the TSRQ was added

“I feel bad about myself for not exercising”). Finally, because the other scales used in the study (e.g., SVS, SWLS, PANAS, PCS) range from 1 to 5 or 1 to 7, the item response scale in BREQ was changed from a 0 to 4 to a 1 to 5 Likert scale. By having similar responses to scales throughout the study, misunderstandings could be avoided. Also, a 1 to 5 Likert scale was used in a validation study of BREQ (Wilson et al., 2002), and a study of 375 exercisers (Thøgersen-Ntoumani & Ntoumanis, 2006). The responses to the scale were kept identical to the original (1 = “not true for me” to 5 = “very true for me”).

Although the scales assessing hedonic well-being had been thoroughly tested, they were included in the pilot. The SWLS (Pavot & Diener, 1993) had an explained variance of 46% (maximum likelihood with varimax rotation, factor loadings from .48 to .84) and an alpha reliability of .79. A trait version of the full 20-item PANAS (Watson et al., 1988) was also included in the pilot. Twelve items had reasonable factor loadings and 10 of these were similar to a short version validated on elderly subjects (Hillerås et al., 1998; Kercher, 1992) and the version used in the NorLAG study (2006). The items with the lowest factor loadings (Negative Affect, NA; ashamed, guilty, hostile, jittery and Positive Affect, PA; strong, proud, attentive, interested) were omitted. Some of these items have been criticised for being unrelated to exercise or making participants angry when filling out the scale (McAuley & Rudolph, 1995; Gauvin & Rejeski, 1993). In the pilot participants particularly noted ‘hostile’ as unsuitable. The alpha reliability was acceptable for the 12-item version ($\alpha = .87$ for NA and $.81$ for PA), and the short version was strongly correlated with the full scale ($r = .96$ for NA and $r = .92$ for PA). Hence, the 12-item version was selected to reduce the total number of items and ease the burden for participants.

The 6-item version of the subjective vitality scale (SVS; Ryan & Frederick, 1997), measuring eudaimonic well-being, was also tested in the pilot. The item loadings ranged from .51 to .91 with 56% explained variance and the alpha reliability was .89. Item 3, “Sometimes I feel so alive I just want to burst”, seemed less suitable for older adults and some found it awkward. The factor analysis indicated the lowest factor loading for this item (.59 without), and the item was therefore replaced with: “I feel I have surplus energy” (“Jeg føler jeg har mye overskudd”).

Instructors

Previous studies have shown that it is possible to educate practitioners to enhance their autonomy supportive behaviour (Williams et al., 2002; 2006; Edmunds et al., 2008). To ensure a certain similarity in behaviour and communication among the 19 instructors, they were trained to be autonomy supportive during two sessions each lasting about 60 min, following the guidelines suggested elsewhere (Deci et al., 1994; Edmunds et al., 2007b; Mageau & Vallerand, 2003). The first session took place before the intervention started, and the second 8 weeks into the intervention period. In the first session an overview of the self-determination theory was presented and guidelines for how to behave in order to be autonomy supportive were given to the instructors. The second session provided the opportunity to remind the instructors of the guidelines, and to keep up the good work towards the end of the intervention period when the participants were getting more tired.

The exercise protocol was fairly instrumental in nature because a precise description of the intervention is important. Therefore, options for choice other than in warm-up routines were limited for participants. The general guidelines were given to the

instructors in order to emphasise positive improvement-based feedback, learning names, involving the participants, and giving a rationale for all exercises.

Blinding of test personnel

Blinded personnel performed testing and participants were told not to tell the test personnel which group they belonged to. Nevertheless, it may have been possible to identify persons in the control group at the physical post-tests due to their unfamiliarity. In most cases, the same person assessed both baseline and post-test. For the post-tests in muscular strength, the test personnel knew the baseline value so they could minimise the number of attempts for the 1RM testing. Questionnaires were completed independent of assessors through self-rating forms.

Adverse events

Adverse events occurring during testing and training are reported in Paper I (p. 120). In total there were few adverse events. Therefore, this relatively high-intensity exercise protocol and the maximal testing does not appear more harmful than expected in the normal activities of daily living in older adults (FHI, 2007).

Statistical analyses

All papers include demographics, means, standard deviations and proportions. Table 2 presents an overview of the statistical analyses used in the four papers. In Paper I and III the traditional null-hypothesis significance test (NHST) is used for evaluating the results, while in Paper I and IV magnitude-based probabilistic inferences are used (Hopkins et al., 2009). Magnitudes of effects are evaluated to a scale corresponding to the

magnitude of correlations (Hopkins et al., 2009; Rosnow & Rosenthal, 1996): <0.2 trivial; 0.2-0.6 small; 0.6-1.2 moderate; >1.2 large. In short, with magnitude-based inferences the effect is evaluated as beneficial or harmful in relation to the smallest substantial effect (0.2 of an SD; Cohen, 1992; Hopkins et al., 2009) and not in relation to zero as NHST. See paper II and IV for a more detailed description of evaluating results using magnitude-based inferences.

Table 2. Statistical analyses used in Paper I-IV

Analyses	Paper			
	I	II	III	IV
Significance testing	x		x	
Magnitude-based probabilistic inferences		x		x
Descriptives	x	x	x	x
Chi-square*	x	x	x	x
Pearson's correlation	x		x	
Paired sample t-test	x		x	
Independent sample t-test	x	x	x	x
Linear regression			x	x
Multiple regression			x	x
Analysis of covariance (ANCOVA)	x			
Mixed modeling		x		x
Bootstrapping*			x	
Cronbach's alpha reliability	x	x	x	x
Factor analyses			x	x

* non-parametric tests

Power analyses

Initial power analysis indicated that 27 participants were needed in each group to detect half a standard deviation difference between the exercise groups and control group for the well-being variables with 80% power and $\alpha = 0.05$. The standard deviations and reliability from the population-based NorLag study (2006) were used in sample size calculations. Although 0.2 of a standard deviation is considered the smallest worthwhile effect (Cohen, 1992; Hopkins et al., 2009), we decided on a detecting a moderate effect

(0.5 SD) because the sample size necessary to detect a small effect with 80% power was ~120. In Paper II and IV we did not use significance testing and by using probability-based inferences in terms of benefit and harm when interpreting the data we can offer more decisive outcomes with smaller samples (Hopkins, 2006; Hopkins et al., 2009).

Missing data

The file was screened for missing items, and the few missing items in the psychometric scales (<2%) appeared random. The missing items were replaced using a general linear model combining main effects of items and subject (Roth et al., 1999). Subjects responding to less than 50% of the items in each scale were omitted from analyses involving that variable (Ware et al., 2000). Table 3 presents an overview of number of participants missing a variable throughout the study.

Table 3. Overview of missing variables throughout the study

Variable	Baseline	Week 7	Week 16	16 mo
SWLS	0	1	1	1
PA	0	1	1	0
NA	2	1	1	0
VITALITY	0	1	1	1
Frequency of physical activity	0	--	--	0
Intrinsic regulation	0	1	--	--
Identified regulation	1	1	--	--
Introjected regulation	2	1	--	--
External regulation	2	1	--	--
Perceived competence	1	3	2	--
Need for autonomy	2	0	2	--
Need for competence	2	0	2	--
Need for relatedness	2	0	2	--
Perceived autonomy support	--	0	1	--
Autonomous orientation	1	--	--	--
Controlled orientation	10	--	--	--
Impersonal orientation	11	--	--	--

Note. Baseline and Week 7; n = 125, Week 16; n = 118, 16 months; n = 62.

RESULTS

In the following section a summary of the results in relation to the two research questions are presented.

Paper I

The aim of Paper I was to examine the effects of the three training types on subjective well-being outcomes (Q1; positive and negative affect and life satisfaction) and physical outcomes (body composition, muscle strength and physical function) from baseline to week 7 and baseline to week 16. In addition, correlations between gains in physical fitness (body composition, muscle strength and functional performance) and changes in indices of subjective well-being were performed.

For the physical outcomes, all three groups increased lean body mass. The strength and functional training groups showed increased muscle strength. Endurance training decreased fat mass and functional training tended to increase physical function more than was found in the controls.

There was a clear positive and moderate net effect of functional training on life satisfaction between baseline and week 7 (ES = .52, 99% CI = .40). Other effects were trivial and unclear (non-significant). Some beneficial gains in positive affect and reductions in negative affect were not significant compared to the control group.

Only two small, but significant, correlations between changes in physical function (chair raise and stair climb) and change in positive affect were observed.

Paper II

The aim of Paper II was to investigate the effects of the three training types on subjective vitality from baseline to week 7 and baseline to week 16 (Q1). In addition, the mediating effects of change in need satisfaction (autonomy, competence and relatedness) and the moderating effect of perceived autonomy support on vitality were investigated at week 7 and week 16 in the three exercise groups (Q2). An interaction term between autonomy support and change in need satisfaction was created to investigate whether the effect of need satisfaction varied as a function of autonomy support (Q2).

There were clear net effects of all three training types on change in vitality at week 7, with a moderate effect for endurance (ES = .70, 99% CI = .44), and small effects for functional (ES = .54, 99% CI = .36) and strength training (ES = .21, 99% CI = .47). At week 16, only endurance training had a clear beneficial net effect on change in vitality (ES = .27, 99% CI = .38).

Perceptions of autonomy support moderated the effect of endurance training on vitality (ES = .66) at week 7, and the effect of functional training at week 16 (ES = .23). Change in need for competence mediated the effect of functional and strength training (ES = .31 and .43, respectively) on change in vitality at week 16.

Two clear interactions were observed: in functional training the effect of change in relatedness was moderated by perceived autonomy support at week 7 (ES = -.42); and in endurance training perceptions of autonomy support moderated the effect of change in competence on vitality at week 16 (ES = .51).

Paper III

The aim of paper III was to test Williams' SDT process model of health behaviour (Williams et al., 2002; 2004). Due to low power, the three exercise groups were analysed as one exercise group versus the controls. The exercise intervention increased participants' autonomous motivation ($\beta = .32$) and perceived competence ($\beta = .15$) from baseline to week 7. In addition, autonomous orientation was related to increases in perceived competence ($\beta = .22$), while controlled orientation gave rise to increased controlled motivation ($\beta = .25$) between baseline and week 7. Short term changes (0 to 7 weeks) in perceived competence and autonomous motivation were positively related to changes in vitality over the 16 week trial ($\beta = .16$ and $.15$, respectively), while changes in controlled motivation were negatively related to both change in vitality and subjective well-being ($\beta = -.13$ and $-.16$, respectively).

As for mediation, bootstrapping analyses supported a mediating effect of autonomous motivation (PE = .23, BCCI = .04 to .57) and perceived competence (PE = .09, BCCI = -.01 to .29) between exercise and vitality. In addition, the effect of autonomous orientation on vitality was mediated by perceptions of competence (PE = .06, BCCI = .01 to .17). The effect of impersonal orientation on subjective well-being was marginally mediated by controlled motivation (PE = -.05, BCCI = -.12 to .00).

Paper IV

The aim of paper IV was to examine the long-term effect (12 months after cessation) of the 16 week trial on all well-being outcomes (Q1) and frequency of physical

activity. In addition, participants' baseline motivational regulation was tested as a moderator of the long-term changes from 0 to 16 months and from 4 to 16 months (Q2).

All three groups had trivial to small reductions in well-being between cessation and follow-up (4 to 16 months), with the largest reductions in strength training in positive affect (ES = -.45) and vitality (ES = -.57). From baseline to follow-up (0 to 16 months) endurance training had small beneficial gains in positive affect (ES = .30) and vitality (ES = .27) and reductions in negative affect (ES = -.23). Strength training had a small possible harmful reduction in vitality (ES = -.30), while effects of functional training were trivial. There were no substantial gains in physical activity.

In the moderator analyses the three groups were collapsed to increase power when including more variables in the model. Between 4 and 16 months introjected and external regulation moderated the effect of exercise on negative affect (ES = .44 and .53, respectively). Introjected regulation also moderated the effect on positive affect (ES = -.50), while autonomous regulation moderated the effect on vitality (ES = .45). Between 0 and 16 months, external regulation moderated positive affect (ES = -.51) and there was a clear moderation of autonomous regulation on the frequency of physical activity (ES = .46).

DISCUSSION

According to Michie and Abraham (2004) three key questions should be considered when intervention results are discussed: 1) Does it work? 2) How well does it work? and 3) How does it work? The following section begins with a discussion on the general methodological limitations of the study, which is related to how well the intervention works (2). Then the discussion moves to research question 1 which relates to the effect of the intervention on well-being (1), before research question 2 is discussed, which is related to how exercise may influence well-being among the elderly (3).

How well does the intervention work? - General methodological considerations

This part of the discussion highlights the implications of the results that can be related to the general methodology and validity of the study.

Statistical validity

Effects and their inferences. The present trial produced a few clear small to moderate net effects (treatment versus control) on well-being indices. Some outcomes showed small to moderate improvements (gains), but due to a small increase in well-being in the controls, several net effects were trivial. The effect sizes are similar to those found in two meta-analyses investigating the effects of exercise on well-being outcomes in the elderly (ES from .15 to .35; Arent et al., 2000; Netz et al., 2005). The effects of the mechanisms (mediators and moderators) on outcomes were generally trivial or small.

The study was designed to detect a significant moderate net effect on well-being outcomes (according to Cohen, 1992; 0.5SD). Several small gains were clear, indicating

that the sample size was sufficient. In addition, the final sample (25 to 33) was similar to that of other studies investigating effects of exercise on indices of well-being (Blumenthal et al., 1991; Cassilhas et al., 2007), life satisfaction (Katula et al., 2008), subjective well-being (Mihalko & McAuley, 1996) or vitality (DeVreede et al., 2007).

In contrast, for the group comparisons and the mechanism analyses some small effects were unclear (Paper II and IV), indicating that the study was somewhat underpowered. When groups are compared, or more than one effect is investigated, there is inflation in errors (Hopkins, 2006). In addition, with small samples the effect-size estimates becomes less precise, due to a larger confidence interval (Shadish et al., 2002). By quadrupling the sample size, the confidence limits are halved (Hopkins, 2006), and an estimated sample of 60 in each group would make the small effects clear.

Two different ways of evaluating the results are used in the present study: the traditional null-hypothesis testing (NHST; Paper I and III); and magnitude-based inferences (Hopkins et al., 2009; Paper II and IV). During my PhD study I was introduced to magnitude-based inferences, and liked the idea of evaluating the results in a more practical way. Further, the NHST has been criticised for being too conservative, and not providing practical information about the size of an effect or whether it is beneficial or harmful (Hopkins et al., 2009). Thus, NHST may be a threat to statistical validity, because there is often a conclusion of “no effect” when the effect may be substantial (Buckworth & Dishman, 2002; Shadish et al., 2002). According to Shadish et al. (2002), NHST will play a less important role in future research because the real world is not as simplistic as “significant or not”. With the method suggested by Hopkins and colleagues (2009), the actual sizes of the effects with their respective confidence limits are reported

and evaluated in relation to the chance of benefit and harm towards the smallest worthwhile effect (-0.2 and 0.2 of an SD). Hence, the results have more practical value and it is up to the reader to decide whether to use the treatment. The results from Paper I were later evaluated probabilistically and there were a few more clear effects than observed with significance testing (Appendix B).

Statistical analyses. Several different statistical tools were used in evaluating the results. Main outcomes were analysed using analyses of covariance (ANCOVA; Paper I) or linear mixed modeling (Paper II and IV). Mixed modeling is considered more appropriate than traditional repeated measures (ANCOVA, ANOVA or MANOVA), because it accounts for the different errors in change scores arising from the different groups and all respondents are included in the model (Hopkins et al., 2009; Gueorguieva & Krystal, 2004). When analysing results reported in Paper I using mixed modeling, the main effects were relatively similar to those obtained with ANCOVA, but also showed a small significant effect of functional training over strength training on life satisfaction between baseline and week 7. Hence, different statistical methods may give different results (see Appendix B).

The SDT-process model (Paper III) was analysed using linear regression and not SEM due to the small sample size (Hu & Bentler, 1999). Mediation was tested with bootstrapping which is considered especially appropriate with small samples and dichotomous variables (Preacher & Hayes, 2004; Shrout & Bolger, 2002). The data was re-sampled 5000 times and the analyses offer confidence intervals for the mediation effect. Baseline value was controlled for in all outcomes (change scores) to correct for regression to the mean (Twisk & Proper, 2004).

As mentioned previously the statistical power was low when including several variables simultaneously. Consequently, the three exercise groups were merged into one group in Paper III and for the moderator analyses in Paper IV. This action may have caused the effect to be biased towards the group with the largest effect, and violated the assumption of independently distributed errors in the different groups (Shadish et al., 2002). This statement was supported in that there was no (significant) difference between exercise and controls for change in vitality between baseline and 4 months (Paper III), while later analyses using mixed modeling and magnitude-based probabilistic inferences showed a small clear effect on vitality only for endurance training (Paper II). Nevertheless, although a 99% confidence interval and bootstrapping was used when evaluating the effects of moderators and mediators (Paper II, III and IV), results should be interpreted with caution because of multiple inferences and the small sample.

Internal validity

The internal validity depends on what causes other than the treatment may relate to the observed effects, and threats to internal validity are often related to the design and procedures of the study. Although the present study used a randomised controlled design, which is considered the “gold standard” when evaluating effects, there are several issues that may potentially have influenced the results.

Design of the study. First, the study was not directly designed only to improve well-being. Physical indicators (strength, muscle mass, functional capacity) were also considered when designing the study and its training protocols. It is likely that larger psychological effects in terms of mediators and outcomes would have been observed with choice of exercise group or prescribed exercise based on participants’ needs or

preferences. However, then the advantages of randomization (equal groups and less anticipation effects) would have been lost.

Second, when investigating the causality of mediators a different design would be preferable. A mediator should precede an observed effect (Kraemer et al., 2002; Shadish et al., 2002). In Paper II, measurement of the change in the mediator and change in the outcome took place simultaneously. Thus it is impossible to identify which comes first, other than theoretically by using the proposed sequence as guidance. In Paper III, a better temporal sequence was used, and change in motivation and competence to week 7 were tested as mediators on well-being over the 16-week trial.

Third, although the training attendance was high and relatively similar for all three groups (Paper I), the three training groups differed in training volume and content. In addition, the endurance training consisted of three types of endurance activities which may have differentially influenced well-being. One major weakness is that perceived exertion (Borg, 1982) was only measured in endurance and functional training and not in the strength training group. Some participants reported fatigue in the strength group (Paper I) and the high-intensity protocol may have caused the trivial/small effects on well-being in this group. However, it is considered difficult to control for differences in volume and intensity between different types of training (Henwood et al., 2008).

Control group. The present study included only a wait-list control group. Because low-intensity training like Tai Chi or toning can have positive effects on well-being (Li et al., 2001; McAuley et al., 2000a), a social and/or active control group (e.g., educational, flexibility or yoga) seems particularly important when investigating psychological outcomes. With the present design involving a wait-list control group we cannot rule out

the effect of social attention or that mastery experiences may occur without strenuous exercise (Buckworth & Dishman, 2002; McAuley et al., 2000a, 2003). In addition, we could not assess the effect of other participants or instructors in the controls because they had no interactions with instructors or other participants (Paper II). An experiment where the environment is manipulated (e.g., autonomy supportive) in one group and comparing that to a neutral group performing the same type of exercise would be preferable when investigating mechanisms. Nevertheless, one important aim with the control group was that it should reflect what older adults typically do in their daily life. In addition, we had the opportunity to compare group effects on outcomes and mechanisms, which has been suggested by several researchers (King et al., 1998; Netz, 2009).

The controls were offered training after their wait-period and their feelings of well-being probably increased at post-test (week 16) due to the effects of positive expectations about taking part in exercise. There were several clear gains (pre-post changes) in the exercise groups, and not offering the controls exercise would possibly result in more clear effects. By offering the controls training, there was no proper control group available at follow-up. However, training groups were compared and additional calculations indicated that there was evidence of individual responses to explain in the moderator analyses (Paper IV). On the other hand, the beneficial effect of offering the controls training was that there was a relatively low attrition in the control group (6 of 39, 14%) and attrition in controls would also be a threat to the validity of the study (Shadish et al., 2002). In addition, there were some ethical concerns about recruiting elderly subjects with a need to exercise and exposing them to familiarization and testing, without then offering those allocated to the control group anything. A clearer indication of why

the controls showed increased well-being would be preferable, but non-reported process-evaluation findings indicated that they looked forward to starting exercising after being on the wait-list.

Recruitment strategies. The recruitment strategies used (posters and advertisements) likely resulted in a relatively healthy, educated and motivated sample with above average well-being (e.g., Blumenthal et al., 1989; Oken et al., 2006). Other strategies were intended in the planning stage (nursing homes), but participation had to be voluntary and the elderly had to be able to complete the relatively extensive training protocol. One advantage of motivated participants is that there were few dropouts (14%) compared to the general population, in which up to 50% drop out of exercise programmes during the first 6 months (Buckworth & Dishman, 2002). Nevertheless, it is likely that with more participants with poorer physical health or well-being at commencement, the effect of the intervention would be greater and not lower. By performing three consecutive rounds, several of the participants in round 2 and 3 were recruited by previous participants. This seemed to result in more frail participants with less experience with exercise.

Measures. There is a plethora of different psychometrics assessing well-being, and they vary widely in terms of what they measure and who they are created for (Bowling, 2005; McAuley & Rudolph, 1995). Netz and colleagues (2005) reported small to moderate differences in exercise effects on different mental health outcomes. Hence, the present results may reflect the scales adopted to measure well-being among the participants.

In the selection process, it was regarded as important to adapt measures that were reliable and had been used extensively to be able to compare results with previous studies. In addition, there was considered to be a greater chance of identifying important mechanisms by including scales that had shown convergent validity with each other in SDT-research (e.g., Adie et al., 2008; Edmunds et al., 2007a; Fortier et al., 2007; Kasser & Ryan, 1999). Exercise-specific well-being scales such as “the Exercise-induced Feeling Inventory” (EFI; Gauvin & Rejeski, 1993; Rejeski et al., 1999) and “the Subjective Exercise Experiences Scale” (SEES; McAuley & Courneya, 1994) were also considered. However, these scales have been criticised in a series of papers (Ekkekakis & Petruzzello, 2000b, 2001a, 2001b). The authors particularly question the importance of interventions not affecting global well-being. Further, because well-being is often assessed outside of exercise (pre- and post-assessments) there is a logical problem with these scales: the feelings or well-being reported are perhaps not affected by the intervention anyway. In addition, in the present study we included a wait-list control group and using specific scales could lead to a wrong conclusion in that the effect of exercise is maximised and the effect of controls is minimised (Ekkekakis & Petruzzello, 2001a, 2001b).

Affect. Due to the total amount of items in the present study, the short-form PANAS was adopted to assess affect. Although the short-form version is validated among older adults (Hillerås et al., 1998; Kercher, 1992), it may be less responsive to change than the full 20-item version (Watson et al., 1988). Both the validation studies and our pilot study were cross-sectional and did not inform about responsiveness in relation to exercise. There were slightly larger changes in positive affect than negative

affect in the present study (Paper I and IV). It may be that adjectives such as “afraid, nervous and scared” are less responsive to change following exercise than “active, alert and enthusiastic” (Gauvin & Rejeski, 1993). Others have indicated that the adjectives used in positive affect are often more actively loaded than the negative affect and that high arousal positive affect (e.g., enthusiastic) could be more amenable to change within exercise (Ekkekakis & Petruzzello, 1999). At the same time, negative affect may be more stable than positive affect or more closely related to personality (Jopp & Rott, 2006; Kunzmann et al., 2000). Thus, the trivial net effects and small changes in negative affect (Paper I and IV) may indicate that the results are influenced by the adjectives used (Diener et al., 1999; Ekkekakis & Petruzzello, 2000; Kunzmann et al. 2000). The inclusion of a more thorough measure of the negative aspect of mental health (e.g., depression) could be preferable.

Life satisfaction. Only functional training had a substantial effect on life satisfaction, otherwise the changes were generally trivial (Paper I and IV). Netz and colleagues also reported trivial effects on life satisfaction following exercise (ES = .08). It may be that the scale (SWLS; Pavot & Diener, 1993) is too global and not strongly affected by exercise. Further, some items are retrospective (see Appendix C) and may be less influenced by ongoing experiences. However, the scale has been found responsive to change following different types of exercise such as strength training (ES = .52; Mihalko & McAuley, 1996), power training (ES = .50; Katula et al., 2008), walking (ES = .24; Fisher & Li, 2004) and tai-chi (ES = .93; Li et al., 2001). Therefore, the trivial changes in life satisfaction in endurance and strength training compared to functional training are not easily explained. One reason could be that functional training improved subjects’

physical function, which again was related to increased life satisfaction in general, but there was no relationship between changes in the two variables (Paper I). In addition, the functional group had the largest change despite having the highest baseline value on life satisfaction. Hence, more research on the effects of different types of training on older adults' life satisfaction is needed.

Vitality. In the present study, the largest effects were found for vitality (Paper II). Netz and colleagues (2005) reported a trivial exercise effect on “energy” among older adults ($ES = .18$). One likely reason for this difference could be that most other studies have used the vitality subscale in SF-36 (Ware & Sherbourne, 1992) or the vigor/fatigue subscale in Profile of Mood States (POMS; McNair et al., 1971). The SF-36 might be insensitive for detecting changes of clinical relevance in normally functioning older adults (Bize et al., 2007; DeVreede et al., 2007; Hill et al., 1996), while the POMS may be most valid in measuring the acute mood states occurring from exercise (O'Connor, 2004). Thus, the subjective vitality scale developed by Ryan and Frederick (1997) seems responsive to exercise, but more studies are needed.

Mediators. Both the need satisfaction scale (BPNES; Vlachopoulos & Michailidou, 2006) and motivation scale (BREQ; Mullan et al., 1997) seemed responsive to change and were related to some of the global well-being outcomes. However, these scales have not been thoroughly tested or validated among the elderly, and using other measures (e.g., BREQ-2; Markland & Tobin, 2004 and PNSE; Wilson et al., 2006b) may provide stronger relationships.

All measures, except the causality orientations, showed high alpha reliability (see Paper I-IV). Therefore, attenuation (random measurement error) is considered relatively

low overall, but some attenuation was likely present when correlating change scores (error in both measurement points). The unequivocal, trivial and small effects are similar to previous studies and this may be related to the different scales and training protocols used. The psychometrics was scored above or below the neutral midpoint at baseline, and some ceiling effects on the scales likely influenced the trivial/small effects. The ceiling effect may reflect the well-functioning sample, but as mentioned previously it could also be a result of the content in the scales. In addition there are some general concerns when using psychometric scales: there could be misunderstandings; some participants tend to avoid extremities in scales; and some may have tried to gain researchers' approval through their answers (Kerlinger, 1964).

Placebo effects. A true placebo (double blind) is impossible in exercise trials, and therefore anticipation bias may occur (Ekkekakis et al., 2000b; Fox et al., 2007; Oken et al., 2006). In addition, we were obliged to inform participants about all the study aims (REK). Desharnais and colleagues (1993) showed that simply by telling participants that the programme was designed to improve well-being, their self-esteem increased. Thus, the self-selected, educated and motivated participants may have gained more because they expected a positive effect (Folkins & Sime, 1981). Further, we did not control for participants' previous exercise experiences, which could result in anticipation effects (Rhodes et al., 1999). One solution to the placebo problems in exercise trials could be to include mechanisms that explain some of the effect that is not related to participants' expectations. Unfortunately, only physical fitness was blinded for participants so the placebo effect could have influenced both the mechanisms and the outcomes. However, by randomizing participants the expectation bias between training groups was minimised.

Procedures and timing of measurement. Participants' test results could potentially influence their well-being because they inform about health or because participants start to do social comparisons (Diener et al., 1999; Rapkin & Schwartz, 2004). Hence, baseline measures were performed before randomization to ensure that participants' answers to the psychological measures were not affected by group assignment and training. Another advantage is that the attention effects were considered low when baseline was assessed. However, there may have been considerable changes in well-being during the two weeks of familiarization and testing, which were not related to the exercise trial.

There are no established guidelines about precisely when to measure the perceptions of the coach or of the other participants (Reinboth et al., 2006; Wilson & Rodgers, 2008). Baseline need satisfaction was measured after familiarization and testing (in week 2). Need satisfaction was considered a mediator and the early measurement was performed to gain some change during the trial. There is a chance that this was not sufficient time to make adequate decisions on perceptions of the environment or the other participants. Hence, the many trivial effects of change in need satisfaction on vitality may have been caused by baseline measurement of need satisfaction being made too early. The perception of autonomy support was measured at week 7 (after 4 weeks of exercise) and week 16 and used as a moderator of the exercise effect on vitality. Hence, the estimation of perceived autonomy support was likely to be relatively accurate. The week 7 assessment was chosen because it was indicated that well-being and mediators might change rapidly (Arent et al., 2000; McAuley et al., 2000b), and also because other SDT studies have used similar time-points (Edmunds et al., 2007a; Fortier et al., 2007).

Ekkekakis et al. (2000b) showed that the affective changes after acute exercise tended to be reversed after about 40 minutes recovery. To ensure that it was not the acute effect of exercise that was assessed, post measurement was performed 3-5 days after the last session before any physical tests. However, it is not known whether participants had their “peak” another day or closer to the last session. Other studies have performed similar procedures (e.g., Mihalko & McAuley, 1996; McAuley et al., 2000a), but timing of measurement should be investigated more thoroughly in future studies.

Training of instructors. There were 19 instructors in the present study, and previous studies have shown that the perceptions of instructors may affect the outcome of exercise (e.g., Edmunds et al., 2008; Fox et al., 2000; Turner et al., 1997). Hence, the instructors were trained to behave and communicate in a similar manner (autonomy supportive) across the three exercise groups. As mentioned previously we could not evaluate the pure effect of autonomy support from instructors with the present design. Nevertheless, the training of instructors was not an attempt to involve another intervention variable, but a desire to even out the groups, and is therefore considered a strength of the study.

Compliance and attrition. Attrition is a considerable threat to internal validity in a randomised controlled trial because it may generate different groups. The functional group had the most dropouts and the differences between groups could potentially be due to different attrition rather than training. Others have also shown lower expectancy on outcomes among dropouts in Norway (Mildestvedt et al., 2008). There was an overall compliance of 91% at week 7 and 86% completed measurements at 16 weeks, which is considered an acceptable rate (Schultz & Grimes, 2002). At follow-up (12 months after

cessation), only 62% of the initial randomised sample completed measurements.

According to Shadish and colleagues (2002) those with low baseline scores tend to drop out, and this was also the case for the present dropouts on several measures (Papers I-IV). Hence, it may be that more motivated participants with positive effects from the trial completed follow-up measurements.

However, reasons for dropping out seemed random and not related to the training protocol (see Figure 3). In addition, only 14% of the participants randomised to training groups dropped out during the trial ($n = 14$), and by giving the dropouts the same value as controls, the overall effect would at most be 14% lower than reported here (see Paper II). Hence, attrition is not likely to have affected the results substantially. Further, the dropouts tended to be less active, have lower education, vitality and competence at baseline and these tended to change more during the trial. Thus, the effects would probably be larger and not lower with higher compliance (Oken et al., 2006).

Attrition causes lower power and one way to maintain power is to do intention-to-treat analyses (ITT). However, effects among the dropouts are unknown and ITT analyses do not inform about those actually receiving the treatment (Shadish et al., 2002). The latest CONSORT-statement advice is to avoid ITT, and instead, describe the dropouts well (Schultz et al., 2010). Thus, all papers include a description of the dropouts.

External validity – To whom do the effects apply?

The recruitment strategies, the relatively extensive training protocol and the inclusion/exclusion criteria probably influenced the final sample. Less than 50% of the initially interested participants were eligible to participate (see Figure 3). The main reasons for ineligibility were age (<70 years), time commitment, or involvement in

regular exercise. Many of those interested were between 60 and 70 years old. Although the definition of 'older' is usually set at 65 years (Chodzko-Zajko et al., 2009; Spirduso et al., 2005), we chose an age limit of 70 years. In addition, participants were only allowed to have had one structured exercise session per week during the last 6 months. Other studies have shown larger effects with sedentary subjects (Netz et al., 2005), and larger gains were expected if the sample reported poor health (Pate et al., 1995). Thus, these two criteria may have affected the results positively. On the other hand, some individuals withdrew because of the intensive protocol (three times per week for 4 months), or were excluded in the medical screening (Figure 3). Hence, a few sedentary individuals with lower initial health who could have benefitted from the trial were lost. The inclusion thresholds were kept as low as possible, but at the same time, the training and testing had to be safe for participants' physical health. Participants with different conditions were included to reflect the older population in general (see Paper 1).

Compared to the general population, the participants showed similar means and standard deviations on positive and negative affect and life satisfaction at baseline as participants aged between 65 and 80 years in the NorLag study (2006). The participants reported having an average of two sessions of physical activity per week before entering the trial (but they were not involved in structured exercise more than once a week). Unfortunately, the measure of activity was weak, with only one item on frequency, and did not inform about type, intensity or duration of the activity. Most reported walking as their main activity when asked in telephone screenings. The measure of physical activity is similar to the one used by Statistics Norway (SSB, 2009). Comparing the present sample with the general population aged 67 to 79 years, they reported slightly lower

activity: 60% of the general population is active for two or more sessions per week, and 42% are active 3-4 times per week (SSB, 2009). Thus, the criterion of excluding those involved in structured exercise may have been successful in generating a more sedentary sample.

The present sample had a similar mean BMI (26.4 ± 3.9) to the population aged 75 years old (between 26.0 and 28.7; FHI, 2000-2003). This is considered slightly overweight, and may indicate that the sample was less active (Hansen et al., 2013). As mentioned previously, the recruitment strategies probably resulted in motivated participants with high levels of education. This assumption is supported in that 41% of the present sample reported having college-level education compared to 15.6% in the general population aged over 67 years in Norway (SSB, 2011). However, education was not substantially related to changes in well-being outcomes (Paper I and IV) and not all types of motivation seem beneficial for well-being outcomes in exercise (Paper IV).

There were few adverse events, which may reflect a well-functioning and healthy sample. The high-intensity strength protocol had trivial effects on well-being and some participants reported fatigue at the end of the programme. In addition, a few dropouts may be related to the total strain of the intervention. Thus, the present results apply to relatively sedentary, but healthy, educated and independent community-dwelling older adults over 70 years of age. One should therefore be careful in generalizing the findings to the more frail elderly or those in residential care.

Does the intervention work?

Research question 1: *What are the effects of three different types of exercise on well-being in older adults?*

Effect of exercise on well-being

Compared to controls. There were some small to moderate net effects of exercise on participants' well-being. More specifically, between baseline and week 7, functional training had a small beneficial effect on life satisfaction (Paper I), while all three exercise types yielded beneficial effects on vitality (Paper II). Between baseline and week 16 (intervention period), only endurance training had a small positive effect on vitality (Paper II), while the effects of functional and strength training were trivial.

Gains. There were several clear within-group improvements at week 7 and week 16. The strength and functional training improved positive affect and vitality at both week 7 and week 16, while functional training also reduced negative affect at week 7. Endurance training improved positive affect at week 7 and vitality at both measurement points. Hence, as mentioned previously, the relatively few clear net effects were due to the increases in the control group towards week 16 (Paper I and II). At follow-up, all three training types had reductions in well-being after cessation (4-16 months) with the least reductions being for endurance training (Paper IV). Consequently, between baseline and follow-up (0-16 months) endurance training had substantial and clear improvements in positive affect and vitality, while negative affect was reduced. The long-term effects of functional training were trivial, while strength training had a possibly harmful effect on vitality at follow-up.

Group comparisons. To find the most effective training interventions for older adults, a comparison between different training types, not merely to a wait-list control group, is needed (King, 2001; King et al., 1998; Netz, 2009; Van der Bij, 2002). Most previous studies have included aerobic or strength training (Netz et al., 2005; Reed & Buch, 2009). Little is known about functional training (Chin et al., 2004; DeVreede et al., 2007; Manini & Pahor, 2009), and few have compared different types of training in the same study (Netz, 2009; Penninx et al., 2002). Thus, one important aim of this study was to investigate the effect of functional training compared to two other more common modes of training.

The group comparisons showed the most beneficial well-being effects for endurance training, followed by functional training, with the least benefit for strength training (Paper I, II, IV and Appendix B). This is congruent with Netz and colleagues (2005) who found that aerobic exercise had the largest effects on well-being. Thus, the most popular activity among Norwegian older adults (SSB, 2009) seems beneficial for well-being (at least vitality). The differences between the training types were small, but may have substantial public health impact considering the many sedentary older adults in Norway (Hansen et al., 2012; Loland, 2004). For now, endurance training is recommended for improving well-being and should be included as a best-practice control when comparing training types in future research. Further, there were a few beneficial effects of functional training compared to strength training (Paper II and IV). Functional training was also the only group with a clear effect on life satisfaction (SWLS, Paper I), which has been proposed as the “only measure” for assessing global quality of life among

older adults (Rejeski & Mihalko, 2001). Hence, functional training may be a cost-effective alternative to traditional strength training in terms of improving well-being.

There are several possible explanations for the beneficial effects of endurance and functional training which are discussed in the following paragraphs.

Duration of the training intervention

The largest effects were generally in the short term (baseline to week 7), with a small decline towards week 16 and additional reductions one year after cessation (Paper I, II and IV). Arent and colleagues (2000) found the largest effects on affect for trials lasting up to 6 weeks. Thus, the few clear effects at week 16 may be due to the duration of the intervention, and it may be that well-being is increased after a few weeks of exercise among the elderly. However, there were gains in positive affect and vitality with functional and strength training from week 7 to week 16 (Paper I and II). For negative outcomes, such as depression, longer duration seems more beneficial (Craft & Landers, 1998; North et al., 1990), but negative affect changed less between 0 and 16 weeks than between 0 and 7 weeks (Paper I). As mentioned previously, the main reason for the relatively few clear effects between baseline and week 16 is probably the increase in the control group due to anticipating effects. Simultaneously there was a small decrease in training groups, probably related to disappointment at post-measurements. Nevertheless, the present study highlights the importance of including multiple assessments of well-being over a trial (McAuley et al., 2005). One reason for the many trivial effects of exercise interventions on well-being could be that only pre- and post-measurements were performed (e.g., Blumenthal et al., 1989; Chin et al., 2004; DeVreede et al., 2007).

Thereby changes are not substantial because they are only registered towards the end of the intervention when well-being is reduced.

From a public health perspective the long-term outcomes may be the most important (Müller-Riemenschneider et al., 2008). Are the participants better than before the trial? McAuley and colleagues (2007) reported higher activity in a walking group compared to a toning group five years after the intervention. In another study, with the same sample, the more active participants (independent of group) reported higher self-efficacy and life satisfaction (McAuley et al., 2005). Therefore, the positive long-term effects of endurance training are probably because this type of training is easier to maintain after cessation compared to strength and functional training (King et al., 1998; McAuley et al., 2007). On the other hand, there were trivial group differences in change in activity, but the assessment was weak, with just one item and only measured at baseline and follow-up (see Paper IV). Nevertheless, few studies have included follow-up measurements, and more research is needed on the long-term effects of different types of exercise (King, 2001; McAuley & Rudolph, 1995; Van der Bij et al., 2002).

To sum up, short-term training may be suggested for improving older adults' well-being independent of exercise type, while endurance training may have more beneficial long-term effects. However, the "duration effect" on well-being may be interacting with several variables. Some psychological mechanisms may change most at the beginning of an intervention and thereby increase well-being in earlier stages (Kraemer et al., 2002; McAuley et al., 2000b). In addition, the effect of duration cannot be considered independent of training intensity and frequency.

Exercise intensity

Because moderate intensity is less demanding and more easily maintained, it is often suggested as beneficial for improving well-being among older adults (Arent et al., 2000; Cassilhas et al., 2007; Netz et al., 2005; Swoap et al., 1994; Tsutsumi et al., 1998). In addition, high-intensity training may produce fatigue or feelings of low energy (Arent et al., 2005; O'Connor & Puetz, 2005). Therefore, the larger well-being effects of endurance and functional training (moderate) over strength training (high) may be related to differences in training intensity. However, the effect of intensity on affect and well-being is debated and can depend on participants' initial health, the outcomes used to assess well-being, and other dose-variables (Ekkekakis & Petruzzello, 1999; Singh et al., 1997). For example, unfit participants may report higher levels of fatigue and RPE compared to fit participants following high intensity training (Reed & Buck, 2009). Hence, frail participants may benefit from low intensity training (e.g., Helbostad et al., 2004), while fit participants may benefit more from moderate and high intensity training. Further, when intensity is high, the duration of trials may have to be shorter with lower training frequency. In addition, there is a need for a healthy older sample when prescribing high intensity training and these participants may be well-functioning, highly motivated and have high well-being at commencement. Thus, the change in well-being following a high intensity protocol may be trivial (Swoap et al., 1994). There are also suggestions that participants are less active in their daily life when in a programme and this in turn influences their overall well-being (King et al., 2000). This may be particularly true when the intensity is high.

It is also suggested that intensity can differentially influence positive and negative aspects of mental health (Ekkekakis & Petruzzello, 1999; Reed & Buck, 2009). For

example, Singh and colleagues (1997) found that high intensity strength training was related to decreased depression, but not improved vitality. It could well be that a variable like vitality (e.g., “I feel energised”) is particularly sensitive for high intensity training. Similar findings were observed between baseline and week 7 in the present study; the high intensity strength training showed the largest reduction of all groups in negative affect, but the smallest change in positive affect, life satisfaction (Paper I) and vitality (Paper II). On the other hand, strength training increased positive affect (Paper I) and vitality (Paper II) from 7 to 16 weeks. The reason may be that the participants adapted to the training intensity after some weeks of exercise. As mentioned previously, investigating dose-response issues may be difficult when comparing different training types because the workloads are different or participants can perceive them very differently (Henwood et al., 2008). One obvious weakness in the current study is the different workloads between groups and the fact that RPE (Borg, 1982) was not measured in the strength group. Hence, it is difficult to conclude that high intensity training is more beneficial for reducing negative emotional states than increasing positive ones.

Although the present results may favour moderate intensity for increasing well-being in the elderly, it is important to note that the beneficial follow-up effects of endurance (Paper IV) cannot be related to intensity. In addition, the participants were randomly allocated and the groups were relatively similar in health at baseline (Paper I). Therefore, intensity by itself may not be an important mechanism variable in the present study. Others have reported little evidence for a dose-response effect on the exercise–well-being relationship among older adults (Netz, 2009; Rejeski & Mihalko, 2001; Spirduso & Cronin, 2001). This claim is also reflected in the large variation across

different studies in terms of duration, intensity, training type, outcomes and samples. Hence, the effect of intensity seems very complex and probably interacts with several other variables in its effect on well-being (Ekkekakis & Petruzzello, 1999), but continuing to investigate possible dose-response effect is important if we are to design more effective training protocols for older adults in the future.

Initial psychological and physical health status of the participants

Initial well-being. The adjustment of baseline indicated that those low in well-being tended to benefit more during the intervention (Paper I and II), and also long-term (Paper IV). Further, those sedentary at commencement increased their activity more at follow-up (Paper IV). Therefore, those low in well-being seem to have more to gain from taking part in exercise, but ceiling effects and/or regression to the mean (especially paper IV with no control group) must also be considered. Nevertheless, after adjustment, small to moderate effects independent of initial well-being were revealed. Thus, the effect would probably be larger with more participants initially low in well-being (Li et al., 2001; Netz et al., 2005; Rejeski & Mihalko, 2001).

Initial physical fitness. The present sample rated their health between “good” and “very good” (Paper I). There was also a tendency for dropouts to report less vigorous activity at baseline (Paper II). Netz and colleagues (2005) found larger effects in studies involving sedentary compared to active older adults, and there is a close relationship between health and well-being in the elderly (Hillerås et al., 1998; Kunzmann et al., 2000; Ryff, 1989). Therefore, the initial physical health of the present sample could have influenced the effect sizes observed, and an unhealthier sample would likely have yielded larger effects both physically and mentally. However, Arent and colleagues (2000) found

no clear effect of initial health on affect, and initial health could not explain the difference observed between groups. On the other hand, the training protocols in the present study were different, and intensity may have interacted with initial health and influenced the trivial results of functional and strength training (Ekkekakis & Petruzzello, 1999).

Closely related to initial health and fitness is the effect of physical improvements, because sedentary individuals may have more to gain physically (Pate et al., 1995). The two recent meta-analyses both reported larger effects on well-being in trials where physical capacity was improved (Arent et al., 2000; Netz et al., 2005). The present study showed some substantial physical improvements (body composition, strength and functional performance), but there were few clear relationships with improved well-being (Paper I). Others have hypothesised that functional improvement is more important than for example strength and power, because of its close relationship to daily function (Netz et al., 2005). Functional training gave the most improvement in life satisfaction and in the functional tests at week 16, but these changes were not related (Paper I). Thus, there was little evidence of a strong impact of physical improvements on well-being outcomes in the present trial. Nevertheless, improvements such as coordination or VO₂ max were not assessed and may have influenced the results (Li et al., 2001). However, due to the positive effects observed in acute studies (e.g., Ekkekakis et al., 1999, 2000a), and training studies with little physical response (e.g., Li et al., 2001), many researchers have questioned whether physical improvements are necessary for increased well-being following exercise (Ekkekakis et al., 2000a; McAuley & Rudolph, 1995; Netz, 2009; Spirduso & Cronin, 2001). Hence, it is suggested that the psychological improvements

occurring through exercise have a stronger influence on well-being in the elderly (Emery & Gatz, 1990; Netz, 2009; Rejeski et al., 2001).

Other possible explanations for the beneficial effects of endurance and functional training

Endurance training may have increased vitality more than functional and strength training because the subjects exercised outdoors (in the natural environment) twice a week. Recent research has shown that outdoor training is more beneficial than indoor training (Coon et al., 2011; Plante et al., 2006; Ryan et al., 2010). Therefore, when comparing results from the different training types, at least for vitality, physical environmental influences should be considered as an explanation for the beneficial effect (Ryan et al., 2010).

Further, exercise can influence well-being independently of fitness improvements, through psychological mechanisms such as feelings of mastery, social relatedness or motivation (McAuley et al., 2000a; Rejeski et al., 2001; Taylor et al., 2004). The strength training only consisted of two to four participants in each group, while endurance and functional training had 12 to 15 participants. Hence, there could be some group effects explaining increases in well-being. In addition, participants' perceptions of how the programme fits with their needs, motivation, values and so on may be important (King et al., 1998). This leads to the discussion of the effects of psychosocial mechanisms.

How does the intervention work?

Research question 2: *Do the social contextual and motivational variables suggested by self-determination theory (SDT) mediate and/or moderate the relations between exercise and well-being in older adults?*

“SDT holds considerable appeal as an approach for understanding both initiation and persistence issues, as it specifies both nature and function of motivation, as well as the socio-contextual conditions that foster (and forestall) motivational development and well-being” (Wilson et al., 2008, p. 251).

A promising theoretical framework for understanding the exercise–well-being relationship is SDT (Deci & Ryan, 1985a, 2000), but to date no study has tested SDT predictions in elderly subjects in an exercise setting. Based on previous SDT and general exercise research, we tested the possible mediating effect of need satisfaction on vitality within the three types of exercise (Paper II), and Williams’ SDT process model of health behaviour and the mediating effect of motivation and perceived competence (Paper III). In addition, the moderating effects of autonomy support (Paper II), causality orientations (Paper III) and regulation of motivation (Paper IV) were tested.

In the following section the SDT variables are discussed, integrated with general research on the elderly within the area of exercise, and elaborated in relation to feelings of mastery, social interactions, autonomy and quality of motivation (enjoyment and value).

The mastery hypothesis – The mediating effect of competence

Older adults may experience reductions in physical capacity and reduced opportunities to demonstrate competence (Heckhausen, 2005; Nelson et al., 2007; Standage & Duda, 2004). Competence reflects the perceptions of accomplishment

(Vlachopoulos & Neikou, 2007) and therefore perceptions of competence may be particularly important for improved well-being in the exercise domain among older adults (Edmunds et al., 2006, 2008; Vlachopoulos & Karavani, 2009; Wilson et al., 2006a, 2009). Several different conceptions of competence are used in the literature (see Fox, 2000 or Skinner, 1996, for an overview). McAuley and colleagues (1999, 2000a, 2003, 2005, 2007) have shown promising results supporting social cognitive theory (Bandura, 1977, 1986,) and positive effects of self-efficacy among older adults in exercise. Two longitudinal SDT-based studies among patients with diabetes found a partial mediation of change in competence between autonomy support and indices of well-being (Williams et al., 2007, 2009). None have tested the effects of the two concepts of competence used within the self-determination theory; perceived competence (PCS; Williams et al., 1996) and need for competence (BPNES; Vlachopoulos & Michailidou, 2006) among older adults in exercise.

Some might ask why two different measures of competence were used in the present study. Firstly, SDT differs between needs and motivational variables. A need is considered a nutriment or inner requirement that is essential for a person's functioning and well-being (Ryan & Deci, 2002). Hence, when needs are satisfied through the social context (e.g., need for competence), people will demonstrate higher perceived competence and autonomous motivation (Deci & Ryan, 2000). Secondly, previous studies testing Williams' process model of health behaviour have used perceived competence (e.g., Fortier et al., 2007; Williams et al., 2004, 2006), while others have used the need for competence when testing relationships to vitality or subjective well-being (Edmunds et al., 2007a; 2008; Vlachopoulos & Karavani, 2009; Wilson et al.,

2006a). Thirdly, the perceived competence scale (PCS example; “I feel confident in my ability to exercise”) is more generic than the competence subscale in the basic psychological needs in exercise scale (BPNES example: “I feel that I execute very effectively the exercises of my training programme”). The PCS made it possible to include the wait-list control group, which would be impossible with the BPNES. Further, additional analyses indicated that change in the two constructs was not strongly correlated (Pearson’s r from $-.11$ to $.12$), while the correlations between the scales at different time-points were moderate (r ’s from $.27$ to $.45$, data not shown). Hence, they may tap different constructs. People have argued for a hierarchical structure for competence from specific to more global (Fox, 2000). For example, Rejeski and Colleagues (2001) found that both satisfaction with physical function and self-efficacy mediated the effect of physical activity on well-being, but the strongest mediator was satisfaction with physical function.

Changes in both need for competence and perceived competence mediated the relationship between exercise and change in vitality (Paper II and III). However, there was no connection between change in perceived competence and increased SWB (Paper III). No mediation of change in need for competence to SWB was found either (data not shown). It could be that competence more strongly affects eudaimonic well-being (i.e., vitality), but the more likely reason is that SWB is a sum score of positive and negative affect and life satisfaction and that these have different correlates (Rejeski & Mihalko, 2001).

SDT focuses heavily on the social context and relatively little on the physical context (i.e., type of training). Edmunds and colleagues (2006) proposed that different

training types could be guided by different needs. Previous studies have found increases in need for competence following aerobic training (Edmunds et al., 2008) and strength training (Wilson et al., 2006a). In the present study there was only an effect of the need for competence on vitality in the two strength groups and not the endurance group (Paper II). McAuley and Courneya (1992) proposed that the connection between efficacy and affect could be related to the challenge in the exercises. In addition, the participants could more easily follow their progress in the two strength groups (see Paper I, p. 117). Hence, the mediating effect of competence in strength and functional training may be explained by both a higher challenge and more visible physical progress in these two groups. At the same time, according to SDT (Deci & Ryan, 2000; 2002) and empirical research findings, physical improvements are not necessary to gain a sense of competence because feelings of competence can also be affected by the social environment (Bandura, 1986; Deci & Ryan, 2000; Williams et al., 2004, 2006). This was supported by the clear interaction effect between perceptions of autonomy support and need for competence on vitality in endurance training (Paper II). Thus, feedback from instructors seems to be particularly important for competence to work on vitality when direct feedback from the exercise itself is lower. In addition, SDT suggest that personality may affect perceptions of competence, and the effect of autonomous orientation on vitality was mediated by perceptions of competence (Paper III). There was also an effect of baseline autonomous motivation on change in perceived competence (Paper III). Hence, not only physical improvements or repeated mastery experiences through exercise improve competence. Studies should continue to investigate the effects of different exercise contexts on need satisfaction and well-being (Edmunds et al., 2006, 2008; Wilson et al., 2009).

The mastery hypothesis was partially supported in that competence influenced participants' vitality, but not their subjective well-being. Another important finding showing the importance of competence was that participants low in competence tended to drop out (Paper III and Paper II). Therefore, practitioners should try to maintain and increase competence within exercise. Self-determination theory suggests three social dimensions to increase competence (but also relatedness and autonomy): autonomy support, structure, and involvement (Deci & Ryan, 1991; Deci et al., 1994; Mageau & Vallerand, 2003; Reeve, 2002). Some practical examples could be: allowing for slow progress; ensuring safety; and positive informative feedback ("very good, this is better than last session"); constructive feedback ("if you try to do it like this it will be easier for you"); informational feedback ("this exercise will strengthen your lower body and make it easier to walk up stairs"). Thus, well-trained and experienced instructors are particularly important to facilitate a sense of competence through their instruction.

The social interaction hypothesis - Influence of social support on well-being

Very few studies have investigated the effect of social variables on well-being in exercise (McAuley et al., 2000a). This is surprising given that social support is an often mentioned predictor of well-being (Baumeister & Leary, 1995; Deci & Ryan, 2000; Diener et al., 1999). In particular two aspects of the exercise environment may affect well-being: perceptions of support from the instructor (Turner et al., 1997; Reinboth & Duda, 2006); and/or the perception of support from other participants (McAuley et al., 2000a). The present study investigated both aspects in relation to vitality (i.e., perceived autonomy support and the need for relatedness).

There was a moderating effect of perceived autonomy support on vitality in the endurance group at week 7 and the functional training group at week 16. There is evidence of direct effects of autonomy support on indices of well-being in both cross-sectional (Adie et al., 2008; Kasser & Ryan, 1999; Vlachopoulos & Karavani, 2009) and longitudinal studies (Reinboth et al., 2006). Ntoumanis (2005) suggested that autonomy support might be more beneficial for those with some experience with exercise. Hence, the few clear moderating effects of autonomy support may reflect that many participants were inexperienced with training, and perhaps preferred an instructor operating in a more controlling manner.

Although there were substantial changes in relatedness, no clear mediating effect of changes in need for relatedness on vitality was found in any group (Paper II). Thus, the social interaction hypothesis was only partially supported, and there are several possible explanations for this, such as measurement issues and the sample under investigation (see also Paper II, p. 415). In addition, both group and home training (working alone) have been shown to positively influence well-being indices (King et al., 2000, 2002). Hence, it may be that feeling connected to others is less important than competence in an exercise setting (Adie et al., 2008; Edmunds et al., 2008; Wilson et al., 2003, 2006a). Further, the lack of effect of change in need for relatedness could be that it was broadly defined and the measure (BPNES) does not state anything about significant others or person of reference (Markland & Tobin, 2010). The relatedness scale in BPNES only taps connections to the other participants, but other types of support might also have influenced well-being (e.g., from family and friends, Kasser & Ryan, 1999). This contention would be equivalent to that of Carstensen (1998), who emphasised the quality

of relationships for older adults' well-being. It could well be that 16 weeks was too short to develop close relationships with the other participants. Another reason for the trivial effects of social interactions could be that the participants reduced other social activities during the programme (DeVreede et al., 2007).

The relationship between social support and well-being in exercise seems very complex and may operate through other channels. The interactions and feedback from instructors and other participants might directly influence well-being, or it may be mediated by increased self-efficacy (McAuley et al., 2000a). McAuley and colleagues (2000b) found that a group environment increased well-being more than training alone, but both groups increased self-efficacy, which was related to increased well-being over three exercise bouts. In a study among students, Halvari and colleagues (2009) indicated high perceived autonomy support was more beneficial for involvement in physical activity when perceived competence was high. In the present trial, need for competence only had an effect on vitality in endurance training when perceptions of autonomy support were high (Paper II). The complexity of the interaction was further shown by the clear moderated mediation of perceived autonomy support and change in relatedness on vitality in functional training (Paper II). Hence, relatedness (support) from the other participants influenced vitality more strongly when perception of autonomy support from the instructor was modest.

The trivial effect of change in social relatedness may also be due to social comparisons. According to Diener and colleagues (1999), who people use as a standard of reference may affect their well-being. One study found that satisfaction with function mediated the relation between social comparison and depression; those with upward

comparisons were less satisfied with function and reported more depression (Neugebauer et al., 2003). There are large differences in physical function in the elderly (Chodzko-Zajko et al., 2009), and this was also the case in the present study. Some participants tended to compare themselves with the others and they may have compared themselves upwards with others in better physical shape, which likely influenced their well-being negatively.

To sum up, the effects of exercise-related social interactions on well-being seem very complex in the elderly and probably interact with other variables. However, researchers should continue to investigate whether these effects are direct or indirect in affecting well-being.

The effect of autonomy – Feeling the origin of one's behaviour

The self-determination theory particularly emphasises feelings of autonomy for optimal function and well-being (Deci & Ryan, 2000; Ryan et al., 2009). Some SDT-based exercise studies have related change in autonomy to vitality (Wilson et al., 2006a), positive affect (Edmunds et al., 2006), or life satisfaction (Edmunds et al., 2007a), while others find no connection (Edmunds et al., 2008; Vlachopoulos & Karavani, 2009). The change in the need for autonomy was not substantially related to changes in vitality during the trial (Paper II). In addition to the discussion in Paper II (page 415), two explanations are suggested. Firstly, the impact of each need may depend on the situation (Deci & Ryan, 2000). In the present study, the participants were home-living and well-functioning, and their need for autonomy in their daily life was probably fulfilled. Therefore, the trivial effect of change in autonomy may be due to the participants' general feelings of autonomy not being particularly influenced by the exercise trial.

Secondly, the design of the trial (RCT with structured training protocols) made it impossible for participants to have many choices with respect to type of exercise and exercises. Thus, the scale used, and particularly the item “I feel very strongly that I have the opportunity to make choices with respect to the way I exercise”, may have been irrelevant for the participants because it was not possible to make choices due to randomization and the standardised protocol. These procedures may have been considered controlling by some participants and dampened the effect of autonomy on general well-being. Future studies should examine the effects of need for autonomy in structured compared to more preferred exercise contexts (Wilson et al., 2003).

Effects of motivation – Quality matters

Motivation, and whether participants felt autonomous with respect to exercise was a better predictor of participants’ well-being in the present study. This is the first study to test the effect of motivation on well-being outcomes among older adults within exercise, and regulation of motivation was included as both a mediator (Paper III) and a moderator (Paper IV) of the exercise well-being effect. Within SDT motivational regulation has also been investigated as a predictor of physical activity and well-being (e.g., Pelletier et al., 2001; Sarrazin et al., 2002; Wilson & Rodgers, 2002), as well as a mediator between environmental influences and positive health behaviours or well-being (e.g., Fortier et al., 2007; Silva et al., 2010; Williams et al., 2004, 2007).

The present study generally supported previous findings on the process model of health behaviour (Fortier et al., 2007; Williams et al., 1996, 2002, 2004). The short-term change in autonomous motivation mediated the effect of the exercise trial on vitality, while controlled motivation was a marginal mediator between impersonal orientation and

subjective well-being (Paper III). There were also beneficial moderating effects of initial autonomous types of regulation on long-term vitality and activity level, while controlled types of motivation were negatively related to positive affect and positively related to negative affect. In line with previous SDT-research there was a tendency for autonomous forms to predict eudaimonic well-being (vitality), while controlled regulation was more closely related to hedonic indicators (e.g., Nix et al., 1999).

The present study supports those suggesting that enjoyment and value (indicators of autonomous motivation) can both moderate and mediate the effect of exercise on well-being among older adults (Elavsky et al., 2005; Rejeski & Mihalko, 2001; Salmon et al., 2003). Hence, motivational regulation for exercise may be particularly useful in explaining well-being outcomes in older adults. Identified regulation (value and importance) is considered particularly useful in explaining positive outcomes of exercise because it is not purely enjoyable (Edmunds et al., 2006; Mullan et al., 1997; Thøgersen-Ntoumani & Ntoumanis, 2006; Wilson et al., 2003). Unfortunately, the intrinsic and identified regulations were collapsed in all analyses (due to high correlation between the two regulations). Hence, with the present data we cannot state whether there is a difference between the two in explaining well-being outcomes in the elderly. Another limitation was that the insufficient sample size made it difficult to investigate differences in motivation across the three training types. Future studies should examine whether some types of training such as hiking are more self-determined than resistance types of exercise.

According to SDT (Deci & Ryan, 1985a, 2000) autonomous types of motivation are nurtured through autonomy support and satisfaction of the three needs or their

causality orientations. Unfortunately, the present study, due to its design, provides very limited information about what influenced participants' motivation during the trial. A few indications can be inferred from the present data: the exercise protocol including autonomy supportive instructors possibly increased participants' autonomous motivation. This is substantiated in that there was no relationship between exercise and change in controlled motivation. In addition, impersonal orientation influenced change in controlled motivation, but the other relationships were unclear (Paper III).

Overall, although little variation was accounted for by SDT variables, the theory is partly supported and still relevant (Baranowski et al 1998). Well-being can be influenced by many variables and there may be several methodological weaknesses (e.g., scales, no change in mediators or outcomes). Hence, known mechanisms with an effect can be manipulated to influence well-being.

FUTURE RESEARCH

Future research should continue to investigate the effects of different training types and possible mechanisms on well-being with a larger sample. A larger sample would also make it possible to test the whole SDT model (see Figure 2), and possibly explain more of the variance in well-being.

Whether findings can be replicated in other groups (i.e., frailer community-dwellers, and rest-home or hospital patients) remains unknown. Thus, a future aim should be to recruit a less healthy sample of older adults. It is possible that the mechanisms work differently with a frail sample and their influence on well-being may be stronger. For example, social interactions could be more important with a less socially active group.

A different design should be considered in future studies. A social control group having the same amount of attention as the training groups without strenuous activity (i.e., yoga, Tai-Chi) would make it possible to determine the exercise effect per se on well-being. In addition, by including an “attention” group, the exercise-specific mechanisms (autonomy support and need satisfaction) can be assessed in the control group. Paper I supported the principle of training specificity in terms of the physiological variables. Future studies should consider designing training protocols for enhancing each participant’s psychological and physical needs (King, 2001; McAuley & Morris, 2007). This would make random allocation difficult, but the effects on well-being may be stronger. Further, autonomy support should increase perceptions of need satisfaction and motivation (Deci & Ryan, 2000). With the present study we can only speculate whether aspects of exercise and/or the environment increased participants’ need satisfaction, motivation and perceptions of competence (Paper II and III). Therefore, a trial comparing

autonomy support to a neutral (or controlling) environment with similar training would be an important extension of the current study. Autonomy support may be directly related to well-being, and it would seem essential to investigate what dimension of the environment (autonomy support, structure or involvement) that contributes in the elderly. It may well be that involvement and structure is central for older people.

Many tenets of SDT have been developed through research on younger populations, and more studies including older subjects are needed. There may be other important predictors or mechanisms of the exercise–well-being relationship among older adults not covered by SDT. For example, there may be other psychological needs and researchers are encouraged to investigate these (Deci & Ryan, 2000). As early as the 1940s, Maslow (1943) suggested that people have a need for security in order to experience self-actualization. Security may be particularly relevant for older adults. The definition of relatedness need may include the concept of security, but future research should continue to refine the measurement of need satisfaction (Markland & Tobin, 2010).

Further, studies should continue to test psychological theories that may help explain the well-being effect in exercise among older adults. Some examples may be aging stereotypes (Leavy, 2003), achievement goal theory (Nicholls, 1984) and goal-theories (Emmons, 1986; Little 1989). Older adults' exercise goals may be a particularly interesting mechanism for explaining well-being (Ryan & Deci, 2001; Diener et al., 1999). Studies within SDT have also shown that that different exercise types may be guided by different motives (Frederick & Ryan, 1993), and that people's motives (goal content) can differentially influence well-being (Kasser & Ryan, 1996; Sheldon et al.,

2004). Future studies should also consider including other eudaimonic well-being indices such as self-actualization or purpose in life (Ryff & Keyes, 1995).

Finally, in the present study motivation for exercise was measured with the BREQ (Mullan et al., 1997). This scale does not involve amotivation. Amotivation is a lack of intention to act, not feeling any value for the activity, and feelings of incompetence (Deci & Ryan, 2000; Standage & Duda, 2004). Those low in competence and physical activity at commencement tended to drop out. It is possible that participants with little or no progress developed perceptions of incompetence, lost their motivation and dropped out of the study (Standage & Duda, 2004). In the planning stages of the trial, amotivation was regarded as less important, because those signing up likely possessed motivation, either extrinsic or intrinsic (Ingledeu & Markland, 2008; Mullan et al., 1997). The possible loss of motivation should have been considered, and could have explained some of the dropouts. Thus, future studies may include BREQ-2 (Markland & Tobin, 2004) or “the exercise motivation scale” (EMS; Li, 1999), which both contain an amotivation dimension.

CONCLUSIONS

The first aim was to investigate the effect of an intervention involving strength, functional or endurance training on indices of hedonic and eudaimonic well-being among older adults. Acknowledging methodological strengths and limitations, the following conclusions can be drawn:

- Endurance training has small to moderate beneficial effects on vitality
- Functional training may be an effective alternative to traditional strength training
- Within-group changes were beneficial, but due to an increase in well-being in the control group, few clear net effects on well-being indices were observed
- The largest beneficial effects were observed at week 7, with small effects for endurance training post-intervention and at follow-up
- Participants with lower well-being at baseline benefitted more over the trial
- There were some small differences between training types with slightly beneficial effects for endurance training
- There was only one possible harmful effect, for strength training on vitality at follow-up, indicating that the protocol was safe for community dwelling older adults

The second aim was to examine why older adults feel better when they exercise, using mechanisms proposed by self-determination theory as a theoretical frame of reference. The following conclusions can be drawn:

- Self-determination theory can be a useful framework for understanding the mechanisms of the well-being effect of exercise in older adults
- Changes in autonomous and controlled types of motivation mediate the effect of exercise on well-being
- Older adults' quality of motivation for exercise at baseline moderated the long term effects of the intervention on well-being
- Change in need for competence mediated the effects of functional and strength training on vitality
- Perception of autonomy support is an important moderator of the effect of endurance training on vitality
- The effect of need for competence and relatedness may interact with autonomy support to influence vitality
- Physical improvements, causality orientations, need for autonomy and relatedness explained little of the well-being effects
- The effects of the mechanisms were generally small or trivial, which may be due to the design, small sample size and methods used.
- Taken together, the pattern of findings indicates that one mechanism alone cannot fully explain the complexity of the exercise–well-being relationship in older adults.

IMPLICATIONS FOR PRACTISE

Endurance training can be recommended for increasing well-being among community-dwelling independent older adults. Activities such as hiking and Nordic Walking are forms of training that most elderly in Norway are involved in (SSB, 2009). Therefore, one should encourage older people to continue to walk and exercise outdoors. Further, functional training may be a cost-effective alternative to traditional strength training for older adults. There is no need for large facilities with expensive equipment, and many people can exercise simultaneously under the supervision of one or two instructors.

In cases of three or more sessions per week with moderate to high intensity, shorter programmes can be recommended. The best option would probably be a consideration of older adults' desire for frequency, and tailoring of the protocols to each individual's needs.

Psychosocial mechanisms seem more important for well-being than physical ones. Therefore, researchers, instructors and others working with older adults should not only focus on improving physical fitness, but also ensure that the participants feel competent and autonomously motivated to exercise. According to SDT, the environment created by instructors is particularly important with this aim in mind. Hence, the use of qualified instructors who know the principles of autonomy support is preferable. Autonomous motivation and competence can be affected through several strategies, such as giving positive and informational feedback, providing meaningful rationales for all exercises, including participants in decisions, and involving them in goal setting (Deci et al., 1994; Mageau & Vallerand, 2003; Williams et al., 1996, 2004). Especially when the exercise

provides little opportunity for notification of physical improvements (e.g. hiking, Nordic Walking), the involvement and feedback received from instructors seem particularly important for older adults' feelings of well-being. Instructors should therefore carefully notify participants and give clear feedback on their improvements during the programme. Other ways of improving competence would be to ensure progress among participants. By starting safe and gradually increasing the challenges, perceptions of competence gradually increase throughout the exercise programme. In the strength and functional training the participants' training load was registered from session to session. This may be another useful tool for increasing competence among older adults.

Motivation matters for effects on well-being, but the quality of motivation matters more. The present study has shown that older adults with controlled types of motivation decreased in well-being during the trial, and those with autonomous types of motivation maintained their well-being and activity level after cessation of the trial. Therefore, practitioners working with older adults should especially nurture their motivation for exercise towards more autonomous forms.

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PAPER I

ORIGINAL ARTICLE

Effects of different types of exercise on muscle mass, strength, function and well-being in elderly

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Abstract

Poor muscle strength and physical function have been associated with higher risk of hospitalisation and lower well-being among the elderly. Physical training increases muscle strength, endurance and physical function as well as psychological outcomes. Exercise among older adults is often used to improve these variables, but few have compared the effects of different types of training in parallel independent groups. Thus, the aim of the present study was to investigate the effect of three different types of training on body composition, muscle strength, physical function and well-being in the elderly. A total of 118 community-dwelling older adults (mean age 74.3, $s = 4.6$ years, 68% women) completed a 13-week randomised controlled exercise-trial involving four groups: traditional strength training (STG), functional strength training (FTG), endurance training (ETG) and control (CON). Stair climb with load improved more in FTG than CON ($P < 0.05$), and the two strength groups performed better in the functional upper body test ($P < 0.05$). STG increased strength more than CON in all exercises ($P < 0.001$), while FTG increased strength more than CON in the chest press, shoulder press and knee extension ($P < 0.05$). Lean body mass (LBM) increased in all training groups, which differed significantly from CON ($P < 0.05$). ETG decreased their fat mass compared to CON ($P < 0.001$). The only significant effect on well-being indices was improved life satisfaction in FTG at week 5 ($P < 0.05$). We also observed significant correlations between change in some of the functional tests and change in positive affect.

All three types of training can enhance physical capacity. Functional strength training can be a cost effective form of training in terms of less demand for instructors and equipment and could be an effective way to improve physical function, strength and indices of well-being in the elderly.

Keywords: Older adults, exercise, ADL, physical function, mental health, RCT

Introduction

From the age of 50 years, a marked reduction in muscle mass, strength, endurance and functional capacity takes place (Hunter, McCarthy, & Bamman, 2004). Poor muscle strength and physical function have been associated with higher risk of hospitalisation (Cawthon et al., 2009), and lower well-being among the elderly (Kunzmann, Little, & Smith, 2000). At the same time, large differences in health have been observed between physically active

and inactive elderly (Valset & Romøren, 2006), indicating that exercise might counteract many of the negative changes associated with increasing age. However, little is known about which type of activity is most beneficial for preserving health and well-being in older adults (Chin, van Poppel, Twisk, & van Mechelen, 2004; Penninx et al., 2002).

Positive effects of strength training have been found on muscle mass and muscle strength (Binder et al., 2005; Hanson et al., 2009; Strasser, Keinrad,

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Haber, & Schobersberger, 2009; Treuth et al., 1994) and on indicators of physical function in activities of daily living, such as walk speed, rising from a chair and climbing stairs (Capodaglio, Capodaglio, Facioli, & Saibene, 2007; Häkkinen, Alen, Kallinen, Newton, & Kraemer, 2000). The effect of endurance training on muscle mass and strength has shown conflicting results (Izquierdo et al., 2004; Pogliaghi, Terziotti, Cevese, Balestreri, & Schena, 2006; Posner et al., 1992; Sipilä, Multanen, Kallinen, Era, & Suominen, 1996; Strasser et al., 2009; Vitiello et al., 1997). Most studies investigating psychological outcomes have examined only one type of training, although one study found that endurance training reduced depression, while no significant effect was observed for strength training (Penninx et al., 2002). The two meta-analyses conducted on effects of exercise on well-being indicate equivocal findings. Arent, Landers and Etnier (2000) found largest effects after strength training, while Netz, Wu, Becker and Tenenbaum (2005) found largest effects after endurance training, closely followed by strength training.

Physical function is considered essential because of its relationship to daily living (Manini & Pahor, 2009). It has been hypothesised that well-being is more closely related to physical function than to muscle strength and endurance capacity (Arent et al., 2000; Netz et al., 2005). Therefore, alternative types of exercise, such as specific functional training, might have more positive effects on physical function and well-being than other types of activity (McAuley, Elavsky, Jerome, Konopack, & Marquez, 2005). However, the few studies on functional training give ambiguous results (Chin et al., 2004; de Vreede, Samson, van Meeteren, Duursma, & Verhaar, 2005; de Vreede et al., 2007; Manini et al., 2007), which might be due to a lack of standardised protocols. Since traditional strength training has been related to increased physical function among the elderly, a step in the right direction may be to perform functional training using external loads. Some studies have increased the load by using ankle weights and rubber bands. In these studies the effects on physical function was positive, but neither muscle strength (de Vreede et al., 2005; Gine-Garriga et al., 2010; Manini et al., 2007) nor well-being (de Vreede et al., 2007) increased. Thus, additionally increasing the load and intensity of functional strength training may be important in order to tease out the effects on muscle strength, physical function and well-being.

With an increasing aging population, it is important to identify effective training programmes that are easy to administer and less expensive in terms of facilities, equipment and instructors than for example traditional strength training. This would

ideally involve examining several types of training simultaneously, but few such studies have been conducted. Accordingly, there is a gap in the existing training literature concerning the effects of different training regimes on older adults (Chin et al., 2004; Manini & Pahor, 2009). Thus, the aim of this study was twofold: 1) To investigate the effectiveness of strength training, functional strength training and endurance training on muscle mass, muscle strength, physical function and well-being in older adults, and 2) to investigate relationships between changes in physical capacity and indices of psychological well-being.

Methods

Study design and participants

The present study is based on a 13-week, single-blinded, randomised controlled exercise-trial. Participants were recruited through advertisements in newspapers and posters. In order to have sufficient control of the participants and their training progress, the 13-week trial was conducted in three cycles, with approximately a third of the participants in each cycle (August to December, 2008, January to May, 2009 and August to December, 2009). During the second and third training cycle some participants were recruited through word of mouth and 'snowballing effects'. Inclusion criteria were: a) at least 70 years of age, b) living at home, c) maximum of one structured exercise session per week during the previous six months, d) that participation in exercise and testing would not be expected to cause any physical harm based on the medical doctor's subjective evaluation (see Figure 1), e) able to read and speak Norwegian. Exclusion criteria were: a) myocardial infarction within the past six months, b) bone mineral density $< 0.84 \text{ g} \cdot \text{cm}^{-2}$ in L2-L4, c) cognitive impairment (< 24 on Mini-Mental State Examination [MMSE]; Folstein, Folstein, & Mchugh, 1975), d) use of corticosteroids during the last six months, e) uncontrolled hypertension.

A total of 284 people responded to the advertisement. Of these, 123 were found to be ineligible based on telephone screenings or withdrew after an information meeting. The main reasons were age (< 70 years), problems with time commitment, or they were already involved in regular exercise programmes. The remaining 161 were invited to a medical screening by two physicians at the intervention site. Based on the medical screening, 12 were excluded. An additional 11 participants withdrew before the baseline testing. This resulted in a final study sample of 138 participants (mean age 74.2, $s = 4.5$ years, 68% females; see Figure 1). All

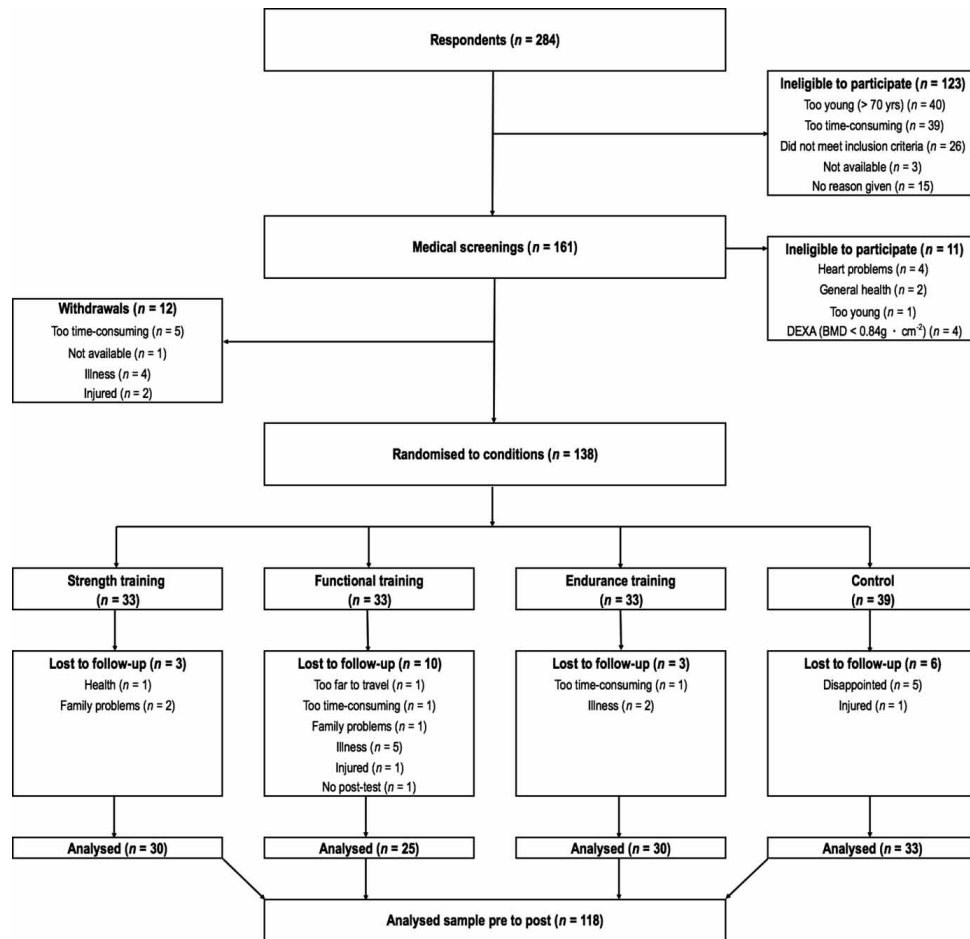


Figure 1. Flow diagram (CONSORT recruitment and retention of participants).

participants provided written informed consent prior to the tests. The study was approved by the Regional Ethics Committee of Southern Norway and the Norwegian Data Inspectorate.

Baseline assessments (T_0). During the first week the participants performed two sessions to familiarise themselves with the physical tests. Demographics and psychological outcomes were collected before the first familiarisation session to ensure that their responses were not influenced by their experiences of the physical challenges. In week two, physical tests were performed on two different days, with at least one day in between. Measurements of body composition were performed during these

two weeks, at a minimum of 24 hours after any strenuous physical activity.

Week 5 assessments (T_1). Psychological measures were reassessed during week 5 of the intervention period based on previous observations showing larger gains in well-being for shorter interventions (Arent et al., 2000; Netz et al., 2005). The questionnaire was sent by mail to the control group.

Post assessments (T_2). About one week after completing the intervention, the participants first completed the psychological questionnaires, and then went through the physical tests and body composition measurements. All participants completed the testing at the intervention site.

Randomisation procedures. The randomisation was performed after baseline testing. Assignment was done by the first two authors who were not involved in the assessments, having only the participant's physical test-scores and number available. To minimise differences between the groups, participants were stratified according to gender, and baseline sum scores on six tests of physical function (stair climb, chair rise, timed up and go, maximal walk speed, functional upper body strength test and 6-minute walk test). Based on these results, matching blocks of four participants were constructed which in turn were randomised to one of the four study groups: a strength training group (STG), a functional strength training group (FTG), an endurance training group (ETG), or a control group (CON; Figure 1). Seven married couples or cohabitants were randomised in pairs to lower their burden in terms of participation.

Measurements

Demographical variables. At baseline participants' living status, educational level, occupation and smoking habits were assessed. In addition, their physical activity level before commencement was assessed with the following question: 'How many hours the past week have you been physically active with the following intensity?' a) Hours light intensity activity (not sweaty or out of breath), and b) Hours high intensity activity (sweaty and breathless). The participants' self-rated health was assessed with one question from the Short-Form Survey (SF-36) (Ware & Sherbourne, 1992): 'In general, would you say your health is; 5 (Excellent), 4 (Very Good), 3 (Good), 2 (Fair) and 1 (Poor).' Diseases and chronic conditions were assessed by the medical doctors at the medical screening.

Body composition. Lean body mass (LBM), fat mass and percentage of body fat were determined by dual energy x-ray absorptiometry (DXA) using a Lunar Prodigy densitometer (GE Medical Systems, Madison, WI). Prior to the DXA scans, participants were asked to avoid training for 24 hours and intake of liquid or food two hours before the scan. Participants lay in a standardised supine position in the machine.

Functional performance. Stair climbing (20 steps, 0.16 m height) under two conditions (Holviala, Sallinen, Kraemer, Alen, & Häkkinen, 2006): without load and with 20 kg load (10 kg weight vest and carrying 5 kg load in each hand). Times were recorded using photo cells (Speedtrap 2, Brower Timing Systems, Utah, USA) placed 0.85 m above the surface at the bottom of the stairs and 0.70 m beyond the last step. Each participant was given two attempts under each

condition, and the best performance was recorded. Coefficient of variation (CV) was 1.3% and 2.1% for unloaded and loaded stair climb, respectively. Chair rise (Csuka & McCarty, 1985): this test consisted of five consecutive rises from a 0.46 m chair. The participants had to touch the backrest each time they sat down and straighten their knees and hip in the upright position (CV = 5.2%). 'Timed Up and Go' test (TUG) (Podsiadlo & Richardson, 1991): Participants were asked to rise from a chair (0.46 m height), walk three metres, turn around a cone, walk back and sit down on the chair. For both chair rise and TUG, each participant was given two attempts and times were recorded with a stopwatch. The best attempts were used in the analyses. Preferred and maximal walk speed (Bohannon, 1997): Walk speed was measured along a straight 10 m track. Participants were first asked to walk at a normal pace (PWS), then to walk as fast as possible without running (MWS). Two attempts were given on each condition. Times were recorded using photo cells (Speedtrap 2, Brower Timing Systems, Utah, USA) placed 0.85 m above the floor. The starting position was 3 m in front of the first set of photo cells. For PWS, the average of the two attempts was recorded, and for MWS the best performance was used. Average walk speed ($\text{m}\cdot\text{s}^{-1}$) for each condition was then calculated (CV for PWS = 1.2% and for MWS = 2.9%). Functional upper body strength test (FUB): Participants lifted dumbbells (one in each hand) five times from a standing position with arms hanging down, onto a shelf at the height of their nose. The load was successively increased with 1 kg until failure (CV = 2.1%). The six-minute walk test (Steffen, Hacker, & Mollinger, 2002) was used to assess walking capacity. The participants were asked to walk as far as possible in six minutes on an indoor track. The distance covered in six minutes was recorded.

Strength tests. Strength tests were performed on machines (Technogym, Selection Line, Gambettola, Italy) using a one repetition maximum test (1RM) in four different exercises: chest press, seated row, shoulder press and knee extension. Before each test, participants performed a standardised warm up protocol consisting of three sets with gradually increasing load and decreasing number of repetitions (10, 5 and 3 repetitions). The first attempt of 1RM was performed with a load of approximately 95% of predicted 1RM based on the familiarisation sessions, and after each successful attempt the load was increased by 2–5% until the participant was unable to perform the required movement. The last acceptable attempt was determined as 1RM. Rest between each attempt was approximately 3 minutes. Verbal encouragement was used to maximise the efforts in each 1RM attempt. Previous studies in our

Table I. Baseline characteristics of analysed participants according to group.

Characteristics	STG (<i>n</i> = 30)	FTG (<i>n</i> = 25)	ETG (<i>n</i> = 30)	CON (<i>n</i> = 33)
Age (years)	75.0 ± 6.0	73.4 ± 3.7	73.9 ± 3.7	74.6 ± 4.5
Females (%)	67	60	70	73
Living alone (%)	50	40	57	58
College Education (%)	60	40	33	39
Occupation (%)	17	16	13	12
Smoking Habits (%)				
Never	60	56	53	49
Former	37	36	30	42
Current	3	8	17	6
MMSE Score (0–30)	29.1 ± 1.2	29.4 ± 1.0	29.2 ± 1.4	28.9 ± 1.4
BMI (kg/m ²)	26.1 ± 4.3	25.8 ± 3.9	26.4 ± 3.5	26.4 ± 3.6
Self rated health (1–5)	3.7 ± 0.8	3.2 ± 0.6	3.5 ± 0.9	3.5 ± 0.7
Physical activity level (%)				
Low intensity > 2 hours/week	53	52	40	55
High intensity > 2 hours/week	13	8	13	3
Energy intake (kJ)	6827 ± 1887	7354 ± 1834	7523 ± 2479	6588 ± 1566
Prevalent diseases (%)				
CVD	39	32	32	39
Diabetes	0	18	8	4
Osteoarthritis	15	21	16	29
Obstructive lung disease	15	0	12	4

Note. Data presented as mean and standard deviation or percentage. BMI = Body Mass Index, MMSE = Mini Mental State Examination, CVD = Cardio vascular disease, STG = Strength training group, FTG = Functional strength training group, ETG = Endurance training group, CON = Control group.

laboratory have shown CV <2% for similar 1 RM tests among younger participants (Paulsen, Myklesstad, & Raastad, 2003).

Nutrition. To estimate nutritional intake, a 24-hour recall interview (Biro, Hulshof, Ovesen, & Amorim Cruz, 2002) was performed before and after the intervention by a trained nutritionist (Table I).

Life satisfaction. Life satisfaction was assessed with the Satisfaction With Life Scale (SWLS; Pavot & Diener, 1993). The SWLS is a short 5-item scale designed to measure the cognitive component of subjective well-being. Example items: 'I am satisfied with my life' and 'The conditions of my life are excellent'. Participants responded to each of the items on a 7-point Likert scale ranging from 'strongly disagree' (1) to 'strongly agree' (7). The average sum of the five items is supposed to reflect general life satisfaction. The scale has moderate temporal stability, but it has also been shown to be related to life events (Pavot & Diener, 1993), and to be sensitive to physical activity in older adults (Katula, Rejeski, & Marsh, 2008). In the present study the reliability was acceptable at all three points of measurement, with Cronbach's alpha at 0.81 (T_0), 0.86 (T_1), and 0.83 (T_2).

Affect. Affect was assessed with a short-version of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The scale

consists of six positive feelings (enthusiastic, inspired, alert, excited, determined, active), and six negative feelings (upset, nervous, afraid, distressed, scared, irritable). Following the stem: 'To what degree have you experienced the following feelings the last 4 weeks?' the participants answered each feeling on a Likert scale from 'not at all' (1) to 'very much' (5). According to Watson et al. (1988) the PANAS is a reliable instrument, independent of response format, time frame or sample. Several exercise studies among the elderly have used the PANAS as a measure of emotional states (Li et al., 2001; Mihalko & McAuley, 1996). In this study the reliability was satisfactory with alphas at 0.85 (T_0), 0.87 (T_1) and 0.82 (T_2) for positive affect, and 0.79 (T_0), 0.85 (T_1), and 0.84 (T_2) for negative affect.

Intervention groups

The study lasted 16 weeks, which included one week to familiarise the participants with the physical tests, one week of baseline testing, 13 weeks of training intervention, and one week of post-testing. During the training period, all exercise groups trained three times per week. Each training session lasted approximately 60 minutes, including warm up and cool down.

*Strength training (STG, *n* = 33).* The STG performed one to three sets of traditional heavy strength training consisting of eight exercises involving all

major muscle groups. The training protocol included three exercises for leg muscles (squat, knee extension, calf raise) and five exercises for upper body muscles (chest press, seated rowing, shoulder press, and abdominal and lower back exercises). The participants could choose between different exercises for abdominal and lower back muscles to ensure variation between sessions. The strength training protocol was a mix between linear periodisation and daily undulating periodisation. The participants started with 8–12 RM sets, and ended with 4–8 RM sets. In two of the three weekly sessions, sets were performed until failure (RM sets). The middle session was performed with a load corresponding to 80–90% of the actual 1 RM load. In the beginning of each session the participants warmed up for 10–15 min on treadmill, bicycle, step machine or rowing machine. The participants exercised in small groups (2–4) and all sessions were supervised by a qualified instructor to ensure safety and quality in the exercise.

Functional strength training (FTG, n = 33). The participants in FTG performed loaded exercises that mimicked activities of daily living with two high intensity and one medium intensity sessions per week. The training protocol consisted of seven exercises: three for leg muscles (rise from chair, case lift and bench-stepping), and four for upper body (push-ups, sit-ups, back raise and functional upper body exercise with dumbbells). Loaded stair climbing was added during the last six weeks. Training was performed as circuit training and the exercises were loaded using weight vests, dumbbells and sand bags. During the first seven weeks, participants performed two sets in all exercises, with one at medium intensity (~80% of 15 RM), and the other at high intensity (15 RM). During the last six weeks, both sets were performed at high intensity and up to 12 RM. All participants registered the load for each exercise, and were encouraged to gradually increase their load throughout the training period. Warm up varied between walking in a circle with different exercises or light aerobics for about 10 minutes. Each training session ended with supervised stretching of major muscle groups. Two instructors were always present for each group of 12 to 15 participants.

Endurance training (ETG, n = 33). Participants in the ETG performed Nordic Walking, aerobics and hiking in rugged terrain on three different days each week. The Nordic Walking sessions included warm up, intervals with slight uphill climbing and cool down. During the first seven weeks the participants performed a total of 4 x 2-minute walking intervals with 1 minute rest in between. During the last six

weeks, they performed 8 x 1-minute walking intervals with 30-second breaks. This change in routine was done to ensure higher intensity and some variation in the exercises. The aerobics were performed indoors and consisted of a 15-minute warm up, 35 minutes of simple exercises to music, and a 10-minute cool down. Hiking was performed in rugged terrain, lasted for 50–55 minutes and ended with stretching of the major lower body muscle groups. Average rating of perceived exertion was moderate on the Borg Scale (Borg, 1982) with ratings of 13.3 for Nordic Walking, 14.2 for aerobics, and 12.8 for hiking. All sessions were supervised by two instructors.

Wait list control group (CON, n = 39). Participants in the control group were asked to continue their daily activities as before. For ethical reasons, and to reduce the number of dropouts, the controls were given the opportunity to participate in one of the exercise groups in the subsequent trial cycle.

Training of instructors

All instructors were trained to provide autonomy-supportive supervision following guidelines emanating from the self-determination theory (Deci & Ryan, 2000; Mageau & Vallerand, 2003). This was done to ensure that the instructors behaved and communicated in a standardised manner across the different training groups. Instructors were trained to emphasise positive, improvement based feedback, provide a sense of social inclusion among participants, learning names and to give a rationale for all exercises. Participants were given the possibility to choose their own warm up routines.

Blinding of test personnel

The test-personnel were blinded for group belongingness, and all participants were instructed not to tell the assessors which intervention group they belonged to. In practice, it seemed possible for the test-personnel to identify persons in CON at post-test due to their insecurity when testing. In most cases, both baseline and post-test were conducted by the same person. For the strength post-tests, the test personnel were given the baseline value so they could minimise the number of attempts in the 1RM testing.

Statistics

Initial power analysis indicated that 27 participants were needed in each group to detect half a standard deviation difference between the exercise groups and control group for the well-being variables with 80%

power and $\alpha = 0.05$. The number of participants needed for the physical tests were well within this range. Analysis of variance (ANOVA), independent sample *t*-tests (equal variances not assumed) and chi-square tests were used to compare groups on demographic and outcome variables at baseline. Differences between the groups were examined with analysis of covariance (ANCOVA), with post-hoc Bonferroni test with the delta means (post score minus pre score), adjusting for baseline value (T_0). Sex was not included as a covariate in the models, owing to the low number of males within each group, and because the distribution of males and females was reasonably similar to that of the population for this age group (Statistics Norway, 2011). Changes within groups were analysed using paired sample *t*-tests. Correlations were performed using Pearson's correlation coefficient. The few missing values in the psychological measurements (<2%) were replaced using a regression equation estimating the missing value based on both the participant's response on completed items in the scale and the value of the missing item generated from the sample data as recommended elsewhere (Roth, Switzer, & Switzer, 1999). Data from participants missing more than 50% of the items were removed from the analyses (Ware, Kosinski, & Dewey, 2000). All data were analysed using SPSS version 15.0 (SPSS, Inc. Chicago, IL), and statistical significance was set at $P < 0.05$.

Results

Descriptive statistics

Of the 138 participants at baseline, 125 were active at week 5, and 118 (mean age 74.3, $s = 4.6$ years, 68% females; see Figure 1) completed the intervention. This gives a total compliance of 86%, and the average training attendance was high in all three exercise groups (92, $s = 6\%$ for STG, 83, $s = 13\%$ in FTG and 87, $s = 10\%$ in ETG).

Initial analyses indicated that the strength group consisted of people with higher education than those in the other groups after the randomisation procedures ($\chi^2 = 20.29$, $P < 0.05$). Level of education was not related to change in any outcome variables. No significant differences between groups were observed for the outcome variables at baseline.

The only significant difference between the drop-outs ($n = 20$) and the participants included in the analyses ($n = 118$) was for the 6-minute walk test ($t = 2.39$ m, $P < 0.05$). Baseline demographic characteristics of included participants are given in Table I. There were no significant differences between groups for the analysed participants.

Relationships at baseline. LBM was strongly correlated with the four strength tests ($r = 0.71$ – 0.82 , $P < 0.001$). Knee extension strength was related to functional performance in all functional tests involving lower body, except chair rise ($r = 0.18$ – 0.45 , $P < 0.05$), all indicating a better performance with increasing 1RM in knee extension. Upper body strength measures were strongly correlated to FUB ($r = 0.81$ – 0.85 , $P < 0.001$). Chair rise performance was related to positive affect ($r = -0.31$, $P < 0.001$) and time used in stair climb with load was significantly correlated to negative affect ($r = 0.23$, $P < 0.05$). Life satisfaction was correlated to time used in chair rise ($r = -0.21$, $P < 0.05$). These relations indicate that better functional performance was related to higher well-being at baseline. No relations between the well-being indices and 1RM strength were observed.

Main analyses

Body composition. Lean body mass increased significantly more than CON in all three training groups during the intervention period ($P < 0.05$; Table II). In addition, ETG decreased fat mass significantly more than CON (mean difference = -1.4 kg, $P < 0.001$). A significant decrease in body fat percentage was observed for STG (mean difference = -1.4% , $P < 0.01$) and ETG (mean difference = -1.8% , $P < 0.001$; Table II) compared to CON. The decrease in body fat percentage in ETG was significantly different from FTG (mean difference = -1.1% , $P < 0.05$). There was a negative effect of baseline for body weight changes, indicating that those low in body weight at baseline increased significantly more ($P < 0.01$).

Muscle strength. The improvements in STG were significantly greater than CON for all the 1RM tests ($P < 0.001$), and than ETG in the upper body strength tests ($P < 0.001$). FTG increased chest press and shoulder press significantly more than ETG and CON ($P < 0.05$) and knee extension more than CON ($P < 0.05$). The only difference between the two strength groups were in seated row where STG improved more than FTG ($P < 0.001$). A significant negative effect of baseline was observed in shoulder press ($P < 0.05$), indicating that the lower the participants performed in shoulder press at baseline the more they improved.

Functional performance. Few significant improvements were observed compared to CON in the functional tests. FTG increased loaded stair climb performance more than CON (mean difference = $0.8s$, $P < 0.05$). All groups increased their performance in the FUB test, and the improvements

Table II. Changes in body composition and 1RM strength at 13 weeks.

Variable	Group	Baseline mean \pm s	Change ^a at 13 weeks (95% CI)	Within-Group Value	P-Diff to CON P-Value ^a
Body weight (kg)	STG	74.2 \pm 15.7	0.7 (0.1 to 1.3)	0.061	1.000
	FTG	74.9 \pm 14.7	0.8 (0.1 to 1.5)	0.011	1.000
	ETG	73.9 \pm 12.2	-0.3 (-0.8 to 0.3)	0.337	1.000
	CON	72.0 \pm 12.8	0.2 (-0.3 to 0.8)	0.401	
Lean body mass (kg)	STG	45.6 \pm 8.9	1.4 (1.0 to 1.9)	0.001	0.001
	FTG	46.4 \pm 8.5	0.8 (0.4 to 1.3)	0.007	0.021
	ETG	44.5 \pm 8.9	1.0 (0.6 to 1.4)	0.001	0.001
	CON	44.3 \pm 8.6	-0.1 (-0.5 to 0.3)	0.580	
Fat mass (kg)	STG	25.3 \pm 8.9	-0.7 (-1.2 to -0.2)	0.014	0.144
	FTG	25.0 \pm 10.5	-0.2 (-0.8 to 0.4)	0.396	1.000
	ETG	27.3 \pm 7.2	-1.3 (-1.8 to -0.8)	0.001	0.001
	CON	25.8 \pm 7.1	0.1 (-0.4 to 0.6)	0.644	
Body fat (%)	STG	35.2 \pm 7.4	-1.3 (-1.9 to -0.7)	0.001	0.009
	FTG	34.4 \pm 10.3	-0.6 (-1.2 to 0.1)	0.083	0.916
	ETG	37.9 \pm 7.3	-1.7 (-2.2 to -1.1)	0.001	0.001
	CON	36.5 \pm 6.6	0.1 (-0.5 to 0.6)	0.817	
Chest press (kg)	STG	28.9 \pm 10.5	6.0 (4.8 to 7.2)	0.001	0.001
	FTG	33.1 \pm 16.0	4.3 (3.0 to 5.7)	0.001	0.001
	ETG	27.9 \pm 10.6	0.3 (-0.9 to 1.6)	0.587	1.000
	CON	29.7 \pm 12.6	0.2 (-1.0 to 1.3)	0.764	
Shoulder press (kg)	STG	13.8 \pm 7.1	4.8 (3.8 to 5.8)	0.001	0.001
	FTG	17.8 \pm 10.3	3.6 (2.4 to 4.8)	0.001	0.001
	ETG	12.2 \pm 6.6	1.0 (-0.2 to 2.1)	0.015	0.444
	CON	14.6 \pm 9.0	-0.4 (-1.5 to 0.6)	0.553	
Seated row (kg)	STG	35.3 \pm 14.7	6.9 (5.3 to 8.5)	0.001	0.001
	FTG	40.8 \pm 15.8	1.7 (-0.1 to 3.5)	0.040	0.373
	ETG	34.1 \pm 12.1	0.6 (-1.0 to 2.2)	0.307	1.000
	CON	35.1 \pm 13.5	-0.5 (-2.0 to 1.0)	0.413	
Knee extension (kg)	STG	46.1 \pm 10.4	15.0 (12.2 to 17.8)	0.001	0.001
	FTG	49.2 \pm 11.5	12.4 (9.2 to 15.6)	0.001	0.035
	ETG	42.9 \pm 11.5	10.7 (7.8 to 13.6)	0.001	0.197
	CON	43.7 \pm 13.3	6.3 (3.5 to 9.1)	0.001	

Note. $n = 118$ from baseline to week 13, STG = Strength training group, FTG = Functional strength training group, ETG = Endurance training group, CON = Control group. * $P < 0.05$, ** $P < 0.01$, significantly different from baseline, ^abaseline value as covariate, CI = Confidence Interval.

in STG and FTG were significantly larger than in ETG and CON ($P < 0.05$). In addition, the exercise groups showed significant within-group improvements in both unloaded and loaded stair climb, chair rise and TUG (see Table III). In the three walk tests (PWS, MWS and 6 min) no significant changes within or between groups were observed. Significant effects of baseline occurred in all functional tests ($P < 0.01$ to $P < 0.001$), except for FUB, indicating that the lower the participants performed at baseline, the more they improved in these tests.

Well-being. The only improvement different from CON in the well-being indices was for FTG in life satisfaction at week 5 (mean difference = 0.57, $P < 0.05$; Table IV). In addition, there were small within-group changes in negative affect at short-term (T_0 to T_1), and positive affect at both time points (week 5 and week 13). Due to the increases in CON,

few significant differences to the exercise groups were observed. Also for the well-being indices, baseline values significantly predicted the changes ($P < 0.001$), again indicating that those low at baseline tended to increase more.

Relationship between changes in LBM, strength, functional performance and well-being variables

Changes in total LBM were positively correlated to changes upper body strength ($r = 0.23-0.42$, $P < 0.05$). The only significant relationship between changes in strength and functional performance was between upper body strength and FUB ($r = 0.33-0.44$, $P < 0.001$). Correlations among change scores for indices of psychological well-being and physiological outcomes are only from baseline (T_0) to post-test (T_2). There were no significant relationships between the changes in indices of

Table III. Changes in functional performance at 13 weeks.

Variable	Group	Baseline mean \pm s	Change ^a at 13 weeks (95% CI)	Within-Group Value	P-Diff to CON P-Value ^a
Stair climb (s)	STG	8.4 \pm 1.9	-0.6 (-1.0 to -0.2)	0.020	1.000
	FTG	8.2 \pm 1.7	-0.9 (-1.4 to -0.5)	0.008	0.719
	ETG	8.6 \pm 2.2	-0.6 (-1.0 to -0.2)	0.007	1.000
	CON	8.9 \pm 2.2	-0.4 (-0.8 to 0.0)	0.004	
Stair climb 20 kg (s)	STG	9.3 \pm 2.3	-0.8 (-1.2 to -0.4)	0.001	0.507
	FTG	9.0 \pm 2.1	-1.1 (-1.5 to -0.7)	0.001	0.040
	ETG	9.8 \pm 2.4	-0.8 (-1.1 to -0.4)	0.001	0.519
	CON	10.2 \pm 3.0	-0.3 (-0.7 to 0.0)	0.026	
Chair raise (s)	STG	11.1 \pm 2.3	-1.0 (-1.4 to -0.5)	0.001	1.000
	FTG	11.5 \pm 2.1	-1.3 (-1.8 to -0.8)	0.001	0.110
	ETG	10.4 \pm 1.7	-0.5 (-0.9 to -0.1)	0.087	1.000
	CON	10.6 \pm 1.9	-0.6 (-1.0 to -0.2)	0.076	
TUG (s)	STG	6.4 \pm 1.1	-0.2 (-0.4 to 0.1)	0.262	1.000
	FTG	6.2 \pm 0.9	-0.3 (-0.5 to 0.0)	0.133	1.000
	ETG	6.2 \pm 1.1	-0.2 (-0.4 to 0.0)	0.071	1.000
	CON	6.8 \pm 1.1	-0.1 (-0.3 to 0.1)	0.109	
Preferred walk speed (m·s ⁻¹)	STG	1.51 \pm 0.24	0.05 (0.00 to 0.10)	0.056	1.000
	FTG	1.58 \pm 0.21	0.06 (0.01 to 0.12)	0.135	1.000
	ETG	1.57 \pm 0.27	0.06 (0.01 to 0.11)	0.067	1.000
	CON	1.45 \pm 0.17	0.02 (-0.03 to 0.07)	0.211	
Maximal walk speed (m·s ⁻¹)	STG	2.16 \pm 0.39	0.07 (-0.02 to 0.15)	0.165	1.000
	FTG	2.28 \pm 0.42	0.12 (0.02 to 0.22)	0.048	0.652
	ETG	2.18 \pm 0.39	-0.02 (-0.11 to 0.06)	0.599	1.000
	CON	2.02 \pm 0.34	0.02 (-0.07 to 0.10)	0.301	
6 min walk-test (m)	STG	590 \pm 68	11 (-7 to 30)	0.090	1.000
	FTG	620 \pm 77	10 (-12 to 31)	0.733	1.000
	ETG	590 \pm 71	11 (-8 to 29)	0.369	1.000
	CON	559 \pm 62	-2 (-21 to 16)	0.773	
Functional upper body (kg)	STG	7.7 \pm 2.5	1.1 (0.8 to 1.5)	0.001	0.010
	FTG	9.3 \pm 2.7	1.4 (1.0 to 1.8)	0.001	0.001
	ETG	7.7 \pm 2.1	0.4 (0.1 to 0.8)	0.011	1.000
	CON	7.8 \pm 2.3	0.4 (0.0 to 0.7)	0.017	

Note. $n = 116$ from baseline to week 13, STG = Strenght training group, FTG = Functional strength training group, ETG = Endurance training group, CON = Control group, TUG = Timed Up and Go. * $P < 0.05$, ** $P < 0.01$, significantly different from baseline, ^a baseline value as covariate, CI = Confidence Interval.

psychological well-being and changes in 1RM strength. Negative correlations between change in positive affect and unloaded and loaded stair climb ($r = -0.23$, $P < 0.05$ and $r = -0.20$, $P < 0.05$, respectively), and chair rise ($r = -0.25$, $P < 0.01$) indicate that a better performance was related to a greater change in positive affect.

Adverse events

A previous back injury recurred during baseline testing for one participant, resulting in withdrawal of both the participant and their cohabitant from the study. The test (V-squat) was removed from the testing protocol after this injury. Four participants in STG reported fatigue at the end of the programme. In FTG, one spinal disc herniation occurred during training and one participant injured the calf muscle during testing. Four participants needed adjusted

training for a period of time due to knee and back pain (two in FTG and two in ETG). Four of the dropouts can be attributed to the total strain of the exercise regimen (see Figure 1).

Discussion

This study adds to the current knowledge by comparing strength-, functional- and endurance-training and evaluating the effect on body composition, muscle strength, physical function and well-being. Compared to the control group, the main findings were that all three training groups increased lean body mass, ETG decreased fat mass and STG and FTG increased strength. The findings concerning physical function generally indicate specific adaptations to the training regimens. FTG increased their life satisfaction more than controls at short-term. There was a tendency for those low at

Table IV. Changes in well-being outcomes at 5 weeks and 13 weeks.

Variable	Group	Baseline mean \pm s	Change ^a at 5 weeks (95% CI)	Within-group P-Value	Diff to CON P-Value ^a	Baseline mean \pm s	Change ^a at 13 weeks (95% CI)	Within-group P-Value	Diff to CON P-Value ^b
Positive affect	STG	3.17 \pm 0.64	0.13 (-0.05 to 0.32)	0.053	1.000	3.21 \pm 0.64	0.24 (0.05 to 0.43)	0.017	1.000
	FTG	3.41 \pm 0.74	0.27 (0.07 to 0.47)	0.003	0.687	3.43 \pm 0.77	0.39 (0.19 to 0.59)	0.005	1.000
	ETG	3.41 \pm 0.71	0.33 (0.14 to 0.52)	0.045	0.212	3.45 \pm 0.68	0.27 (0.08 to 0.45)	0.144	1.000
	CON	3.32 \pm 0.82	0.05 (-0.12 to 0.23)	0.577		3.34 \pm 0.79	0.23 (0.06 to 0.41)	0.009	
Negative affect	STG	1.97 \pm 0.75	-0.29 (-0.49 to -0.08)	0.006	0.328	1.92 \pm 0.68	-0.07 (-0.28 to 0.14)	0.374	1.000
	FTG	1.79 \pm 0.78	-0.20 (-0.42 to 0.01)	0.027	1.000	1.76 \pm 0.81	0.03 (-0.20 to 0.25)	0.624	1.000
	ETG	1.82 \pm 0.62	-0.23 (-0.44 to -0.02)	0.105	0.781	1.82 \pm 0.63	-0.09 (-0.30 to 0.12)	0.57	1.000
	CON	1.88 \pm 0.66	-0.01 (-0.21 to 0.18)	0.899		1.92 \pm 0.65	-0.03 (-0.24 to 0.17)	0.64	
Life satisfaction	STG	4.81 \pm 1.15	-0.01 (-0.27 to 0.25)	0.911	1.000	4.94 \pm 1.06	0.03 (-0.19 to 0.25)	0.814	1.000
	FTG	5.09 \pm 0.99	0.40 (0.12 to 0.68)	0.004	0.019	5.12 \pm 1.01	0.21 (-0.02 to 0.45)	0.174	1.000
	ETG	4.92 \pm 0.92	0.22 (-0.04 to 0.48)	0.219	0.195	4.91 \pm 0.94	0.09 (-0.12 to 0.31)	0.392	1.000
	CON	4.82 \pm 1.22	-0.17 (-0.42 to 0.07)	0.228		4.89 \pm 1.29	0.20 (0.00 to 0.41)	0.036	

Nota. n = 125 from baseline (T₀) to week 5 (T₁), n = 118 from baseline (T₀) to week 13 (T₂), STG = Straight training group, FTG = Functional strength training group, ETG = Endurance training group, CON = Control group. *P < 0.05, **P < 0.01, significantly different from baseline, ^a baseline value as covariate, ^b bonferroni adjustment, CI = Confidence Interval.

baseline in physical function and well-being to improve more following the trial. Another important finding was that the functional strength training improved muscle strength and functional performance similarly to the heavy strength training group. Further, improvements in some of the functional tests correlated with changes in positive affect over the intervention period, indicating that change in physical function might affect indicators of well-being among older adults.

Despite the present study employing a standardised functional strength training protocol, in terms of exercises, load, progression and intensity, few significant differences vs controls were observed in functional performance. Other studies that have investigated the effects of functional training, have used different protocols for both the training and measures of physical function and for this reason it is difficult to compare results between studies (Chin et al., 2004; de Vreede et al., 2005; Gine-Garriga et al., 2010; Manini et al., 2007). Little effect has been found in more game-like functional training (Chin et al., 2004), while studies using loaded functional training have found positive effects on physical function (de Vreede et al., 2005; Gine-Garriga et al., 2010; Manini et al., 2007). In the present study, improvements in functional performance were greater for those with lower physical function at baseline. Thus, one might suggest that introducing a regular exercise programme for the elderly is more beneficial for people who have a low function at baseline, and that it is difficult to improve physical function in older adults with an initial high baseline physical function.

The results from the strength tests reflect the loads and muscle groups involved in the different training protocols, and that a greater increase in strength was observed with higher training resistance. Thus, traditional strength training seems superior to endurance training and no training in terms of improved strength. However, although not to the same extent as STG, FTG also increased their strength in both upper and lower body, which is in contrast to previous studies (de Vreede et al., 2005; Manini et al., 2007). One factor contributing to the positive effects of functional strength training in the present study could be the registration of load, which ensured a gradual progression for each individual. There were significant correlations between muscle strength and functional performance at baseline, which support the importance of strength for older adults when it comes to maintaining physical function (Baker et al., 2007; Holviala et al., 2006). On the other hand, no significant correlation between changes in lower body strength and changes in functional performance was found, possibly because the participants were relatively well-functioning at

baseline and therefore only small increases in the functional tests were observed with increased leg strength.

Positive changes in body composition, such as increased LBM and/or decreased fat mass, are of major importance for the elderly because these changes may directly affect muscle strength, physical function and general health status. Therefore, the increase in LBM in all training groups compared with controls, and the correlations between the changes in LBM and upper body strength, reinforce the importance of maintaining or increasing muscle mass in older adults. Results showed gains in muscle mass even in ETG, indicating that not only strength training, but also endurance training can increase LBM in older adults. Studies investigating the effect of endurance training on LBM are equivocal, with some studies showing an increase in LBM following endurance training in the elderly (Posner et al., 1992; Vitiello et al., 1997) while others report no effect of endurance training on LBM (Coggan et al., 1992; Izquierdo et al., 2004; Pogliaghi et al., 2006; Strasser et al., 2009). The ETG performed uphill intervals and the indoor aerobic sessions included squats with body weight. This may have resulted in a higher strain on the lower body muscles compared to previous studies involving only walking or cycling (Coggan et al., 1992; Izquierdo et al., 2004; Pogliaghi et al., 2006; Strasser et al., 2009). The cited studies may also have failed to show significant effects as a result of being underpowered. ETG decreased their fat mass significantly more than FTG and CON, corroborating previous studies investigating the effect of endurance training on fat mass among the elderly (Coggan et al., 1992; Strasser et al., 2009). According to the 24-hour recall interviews, there were no differences in energy intake between the groups either before or after the intervention. The difference between the groups may be explained by differences in energy expenditure, although this was not measured.

In terms of indices of psychological well-being, only FTG increased their life satisfaction more than the control group during the first part of the intervention. The change in life satisfaction in FTG may be due to a more observable change in daily function, which is more salient for older adults (Rejeski & Mihalko, 2001). Rejeski and Mihalko (2001) have suggested that life satisfaction is perhaps the most important outcome when investigating quality of life among older adults, which adds even more credit to the functional training programme in the present study. Our findings are in contrast to previous studies which found no effect of functional training on indicators of well-being among older adults (Chin et al., 2004; de Vreede et al., 2007). As mentioned previously, it is difficult to compare the

present results with the studies mentioned because of the difference in the protocols, measures of well-being and time-points for measurements.

The largest increase in all well-being indices tended to occur during the first five weeks of the intervention, which is in accordance with two meta-analyses which found largest effects on well-being for short-term trials (Arent et al., 2000; Netz et al., 2005). This might be due to a rapid progress and more frequently felt mastery experiences in the beginning of a trial (McAuley et al., 2005). These findings highlight the importance of assessing indicators of psychological well-being at multiple stages during a trial. The control group increased their positive affect and life satisfaction from baseline to post-intervention, while the training groups tended to level off after the mid-assessment. Consequently, over the total trial no differences vs CON were observed. This may reflect positive expectations in the control group, as they were about to start training in the subsequent cycle. In addition, well-being might have decreased within some exercise participants towards the end of the intervention period because they wanted to continue training. Process evaluation findings supported these suggestions. A social control group getting the same attention as the training groups without strenuous exercise (e.g., social programme or flexibility) would have been useful to further elaborate these findings.

Increases in physical function have been hypothesised as a potential mediator of the exercise-well-being relationship because they are closely related to their daily function (McAuley et al., 2005; McAuley & Morris, 2007; Rejeski & Mihalko, 2001). We found significant correlations between changes in some of the functional tests and positive affect, indicating a possible mediating effect. The correlations were small, and future studies should more thoroughly investigate both the physiological and psychological mechanism of the exercise-well-being relationship. In accordance with other studies (Perrig-Chiello, Perrig, Ehrensam, Staehelin, & Krings, 1998), no relationship between increases in 1RM muscle strength and well-being was observed.

The present study has some limitations. First, as seen in other studies using similar recruitment procedures (de Vreede et al., 2005; de Vreede et al., 2007), the volunteers were in general good health and well educated. Second, the intervention was of relatively short duration. Little is known about long-term effects, especially for physical function and functional training (Manini & Pahor, 2009). It is also noteworthy that a lower baseline performance was observed among the dropouts, which may indicate that the training was too hard for some of the participants. Regardless, there were few adverse events and dropouts directly related to the

testing and training protocol. This indicates that high intensity training is well tolerated in older adults and that these training protocols can lead to positive changes even in the well-functioning elderly.

In conclusion, all training protocols had a positive influence on body composition and muscle strength. Consequently, they could be used as effective tools for improving health in the elderly. Furthermore, the positive effects related to the different training protocols give room for individualised training protocols in terms of personal preferences, physical status and the main goals for the training. Finally, the loaded functional training yielded positive effects on both strength and well-being, which may be important for activities of daily living and continued exercise behaviour. Since functional strength training is more cost effective than traditional strength training and can be performed at home or in care facilities, this type of training may be preferable in an older population.

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PAPER II



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Effects of three training types on vitality among older adults: A self-determination theory perspective

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ABSTRACT

Objectives: To investigate effects of endurance, functional and strength training on subjective vitality in older adults. Using the self-determination theory (SDT) framework we tested the moderating effects of autonomy support and mediating effects of need satisfaction on participants' changes in vitality.

Design: Parallel-groups randomized controlled trial.

Methods: 138 older adults ($M = 74.2$ years, $SD = 4.5$) were randomized to a training group or wait-list control, with assessments at baseline, at 7 weeks (short term), and 16 weeks (long term). Mixed models provided estimates of treatment effects, with covariates for moderating effects of autonomy support and mediating effects of need satisfaction (autonomy, competence, relatedness). Inferences were based on uncertainty in standardized effect-sizes (ES) in relation to a smallest important ES of 0.20.

Results: At short term, effects on vitality were moderate for endurance training ($ES = .70, \pm .44$), and small for functional ($ES = .54, \pm .36$) and strength training ($ES = .21, \pm .47$). At long term only endurance training had a clear effect on vitality ($ES = .27, \pm .38$). Perceived autonomy support moderated the effect of endurance training at short term ($ES = .66, \pm .66$), and functional training at long term ($ES = .23, \pm .40$). Change in competence mediated the effect of functional and strength training at long term, while in endurance training high perceptions of autonomy support moderated the mediation effect of competence on vitality.

Conclusions: Endurance training is recommended for increasing subjective vitality in older adults. Moderating effects of autonomy support and mediating effects of need satisfaction are partially consistent with self-determination theory.

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Introduction

Psychological well-being in old age has gained increasing attention in the last decade (Chida & Steptoe, 2008; Penninx et al., 2000), and having a sense of vitality is considered an important indicator of well-being (Benyamini, Idler, Leventhal, & Leventhal, 2000; Kasser & Ryan, 1999; Ryan & Deci, 2001). Vitality, defined as "one's conscious experience of possessing energy and aliveness" (Ryan & Frederick, 1997), is associated with better objective and subjective health (Benyamini et al., 2000; Penninx et al., 2000; Ryan & Frederick, 1997), less risk of mortality and disability (Chida & Steptoe, 2008; Penninx et al., 2000), and less depression and anxiety (Kasser & Ryan, 1999; Ryan & Frederick, 1997). Vitality may decline with increasing age, and investigating ways to enhance

vitality among older adults is considered important (Benyamini et al., 2000; Penninx et al., 1998).

Exercise may be a valuable approach to increase vitality (Ryan & Frederick, 1997; Ryan, Williams, Patrick, & Deci, 2009), but experimental studies with older adults have been equivocal. With aerobic training one study found small reductions in vitality in a walking group (Oken et al., 2006), while among younger participants outdoor aerobic exercise increased vitality more than indoor aerobic exercise (Plante, Cage, Clements, & Stover, 2006; Ryan et al., 2010). Effects of functional types of training, involving exercises with a focus on practicing activities of daily living in a progressively challenging manner (Manini & Pahor, 2009), have also been ambiguous, with both positive (Whitehurst, Johnson, Parker, Brown, & Ford, 2005) and trivial effects on vitality (Chin, van Poppel, Twisk, & van Mechelen, 2004; DeVreede et al., 2007). Lastly, some studies found a trivial effect of strength training (Chin et al., 2004; DeVreede et al., 2007), while others have reported positive changes (Cassilhas et al., 2007; Tsutsumi et al., 1998). Taken

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together, these results suggest that more research is needed on the effects of exercise on vitality, with attention to the methodological aspects that might account for some of the differences between studies. Few have compared different types of exercise simultaneously, and the duration of the trial and the scales used to tap vitality may affect the results (Arent, Landers, & Etnier, 2000; Netz, Wu, Becker, & Tenenbaum, 2005). Thus, the first aim of this study was to investigate the effect of three types of exercise on older adults' subjective vitality, measuring vitality at multiple times during a trail using a different vitality scale.

Although there is general consensus about positive effects of exercise on indicators of well-being among older adults (Arent et al., 2000; Netz et al., 2005), less is known about the factors that moderate and mediate the effects (McAuley et al., 2000; Rejeski & Mihalko, 2001). Changes in vitality can be a function not only of objective parameters of the exercise program, but also psychological factors (Nix, Ryan, Manly, & Deci, 1999; Ryan et al., 2009). Self-determination theory (SDT; Deci & Ryan, 1991, 2000) has emerged as an appropriate framework for understanding why people feel better when they exercise (Edmunds, Ntoumanis, & Duda, 2007a; Ryan et al., 2009; Wilson, Mack, & Grattan, 2008). The basic need theory (BNT, Deci & Ryan, 2000; Ryan & Deci, 2002), a sub-theory within SDT, was developed to explain how the social context influence people's well-being through the three psychological needs for autonomy, competence and relatedness. Competence refers to the need to feel a sense of mastery and effectiveness within one's environment, autonomy refers to the feeling of being the origin of one's behavior and acting in accordance with personal values, and relatedness concern the feeling of having a meaningful connection and support from others (Deci & Ryan, 1991; Ryan & Deci, 2002). Self-determination theory further specifies three dimensions forming a need supporting environment: autonomy support, structure and involvement. Autonomy support involves provision of opportunities for choice, minimized pressure and rationale for all exercises. Structure involves providing informational feedback and clear expectations about the outcomes of exercise. Involvement concerns the instructors' interest and care for participants and their well-being (Deci & Ryan, 1991; Mageau & Vallerand, 2003; Ryan & Deci, 2002).¹

Experimental studies, focusing on the SDT process model of health behavior, have shown that instructor's can be educated to behave autonomy supportive, and that an autonomy supportive climate is related to an increase in perceived competence and self-determined motivation again leading to more positive health behavior (see Fortièr, Williams, Sweet, & Patrick, 2009 for an overview). According to BNT, the effect of an autonomy supportive context on well-being is also mediated by the perception of need satisfaction (Deci & Ryan, 2000). Unfortunately, there is little research on the tenets of BNT in the exercise domain (Wilson et al., 2008). Cross-sectional studies among younger participants have generally supported BNT in that the perceptions of autonomy support in exercise is positively related to vitality through need satisfaction (Adie, Duda, & Ntoumanis, 2008; Vlachopoulos & Karavani, 2009). One recent longitudinal study showed that change in competence and autonomy was related to change in vitality among female exercise participants in a 12-week resistance

program (Wilson, Longley, Muon, Rodgers, & Murray, 2006), while another reported that autonomy predicted life satisfaction in a 3-months exercise prescription programme (Edmunds et al., 2007a). In a subesequent experimental study among female exercises, a 10-week SDT-based teaching style cardio-program increased participants perceptions of structure, involvement, relatedness, competence and positive affect more than a typical teaching style (Edmunds, Ntoumanis, & Duda, 2008).

Most studies involve already active young adults or females, and evidence about SDT's predictions among older adults in general and within the exercise context is lacking (Ryan & LaGuardia, 2000). Several authors have also called for more research on the roles of autonomy support and need satisfaction in predicting the psychological outcomes of different types of exercise (Adie et al., 2008; Edmunds et al., 2008; Vlachopoulos & Karavani, 2009; Wilson, Mack, Blanchard, & Gray, 2009). Autonomy support and need satisfaction are theorized to operate in a complementary fashion affecting well-being (Deci & Ryan, 2000; Ryan & Deci, 2002). However, cross-sectional studies have shown that there is a direct effect of autonomy support on vitality even after controlling for need satisfaction (Adie et al., 2008; Vlachopoulos & Karavani, 2009). Thus, autonomy support may directly affect vitality and therefore the strength of the relation between different exercise conditions and vitality depends on the autonomy supportive climate created by instructors. This is by definition a moderation relationship. Many SDT-based experimental studies contrast autonomy support versus control or standard treatment and look for interactions (see Fortièr et al., 2009). However, such interactions have not been investigated with different exercise protocols or among older adults. This would seem important in that different characteristics of the exercise protocol in terms of how the groups and programs are organized may affect the participants' perceptions of autonomy support. According to Deci and Ryan (1991) moderate structure is beneficial, and there could be differences in perceptions of autonomy support between a highly structured strength training protocol and an endurance group-based protocol. Therefore, the second aim of the study was to investigate whether autonomy support moderates the exercise-vitality relation in three different types of exercise.

All three psychological needs are considered beneficial for well-being, but the relative role of each need for vitality may be different within training types (Deci & Ryan, 2000; Ryan & LaGuardia, 2000). For example, it is possible that a typical strength training effect on vitality is mainly mediated by changes in competence (Wilson et al., 2006), whereas in a group-based endurance training programme the need for relatedness is prominent (Edmunds et al., 2008). Edmunds et al. (2008) found an increase in competence in the control condition, and suggested that when participants can manage the exercise tasks, the program itself may increase feelings of competence. Hence, the different protocols may differentially affect participants' perceptions of need satisfaction and again their vitality. Consequently, the third aim was to examine the mediating role of each need in the relation between three types of exercise and vitality.

Adie et al. (2008) found a partial mediation of competence on the autonomy support-vitality relation, and hypothesized that the strength of the relation between autonomy support and need for competence could vary as a function of setting and age. To address this, our fourth aim was to evaluate the effect of the interaction between perceived autonomy support and change in need satisfaction on the exercise-vitality relationship. This moderated-mediation analysis would be pertinent to investigate the complimentary effect of autonomy support and need satisfaction on vitality. At last, considering the studies finding largest effect for shorter trials (Arent et al., 2000; Netz et al., 2005), we included

¹ The social environment created by significant others involving all three dimensions have been labeled both a need supportive environment and autonomy supportive environment in the literature (e.g., Mageau & Vallerand, 2003; Markland & Tobin, 2010). The definition of autonomy support and the measure (HCCQ) provided by Williams et al. (1996, p. 117) suggest that autonomy support involves all three factors. Therefore, when referring to an autonomy supportive context in the present paper we refer to a context involving all three dimensions suggested by Deci and Ryan (1991).

assessment of all variables at baseline, Week 7 and Week 16 to evaluate both short- and long-term effects. This would also address the paucity of information about the time scale of changes in autonomy support, need satisfaction and vitality, and again the extent to which these variables help explain vitality at various stages of a trial (Wilson et al., 2008).

Method

Study design and participants

The present study is based on a 16-week randomized controlled exercise trial with four groups and measurements at baseline, Week 7 and Week 16. The primary purpose of this trial was to investigate effects of three different types of training on muscle mass, strength, physical function and well-being in older adults. For a detailed description of the recruitment procedures, inclusion and exclusion criteria, randomization procedures, flow-chart and training protocols see Solberg et al. (in press). In short, a total of 284 potential participants responded to the posters and local newspaper advertisements. After a telephone interview or informational meeting, 123 respondents were deemed ineligible due to the inclusion/exclusion criteria. Another 12 participants were excluded after a medical screening due to health constraints, and 11 withdrew from the study before physical tests. To minimize differences between the groups the remaining 138 participants ($M = 74.2$ years, $SD = 4.5$; 68% females) were stratified according to gender, and their baseline sum-score on six tests of physical function (stair climb, chair rise, timed up and go, maximal walk speed, functional upper body strength test and 6-min walk test). Then they were allocated to one of four treatments: traditional strength training, functional strength training, endurance training, and wait-list control. All participants provided written informed consent prior to the trial, and the study was approved by the Regional Ethics Committee of Southern Norway and the Norwegian Data Inspectorate.

Treatments

The training programs were carried out three times per week for 13 weeks, and each session lasted 60 min including 10 min general warm up and 10 min instructor led stretching. Participants exercised in groups of two to four with one instructor in strength training, and 12 to 15 in functional and endurance training with two instructors supervising each session. The same instructors followed their group throughout the program.

Endurance training

Participants performed two outdoor and one indoor aerobic session on three different days per week. The outdoor sessions consisted of one with Nordic walking, including intervals of 1–2 min work with slight uphill climbing, and one involving hiking performed in rugged terrain. The indoor aerobics consisted of a warm up, 35–40 min of simple exercises to music and a cool down. Average rating of perceived exertion (RPE) was 13.4 ($SD = 2.3$) on the 6–20 Borg scale (Borg, 1982) across the three sessions.

Functional training

Two high-intensity and one medium-intensity session (80% load) per week in eight loaded exercises mimicking activities of daily living (e.g., chair raise, case lifts, stair climbing) was carried out as a circuit training. Participants did two sets, starting with 15 RM (repetition maximum) the first 7 weeks and 12 RM the last 6 weeks. Load was increased gradually with weight-vests and

dumbbells. Average RPE was 14.5 ($SD = 0.9$) and in the range between moderate and vigorous intensity (Borg, 1982). Warm up varied between walking in circle with different exercises or aerobic.

Strength training

The intervention was a mix between linear periodisation and daily undulating periodisation starting with 8–12 RM, and ending with 4–8 RM while increasing load. Two sessions per week were high in intensity (until failure), and one was of medium intensity (80% of 10 RM). Participants did one to three sets each of eight traditional exercises: squat, knee extension, calf raise, chest press, seated row, shoulder press, abdominals and lower-back exercises. RPE was not assessed in strength training as this was designed as a high-intensity protocol using repetition maximum. Each session started with warm up on a treadmill, bicycle, step machine or rowing machine.

Wait-list control group

Participants in the control group were asked to continue their daily activities as before, and not to start any new training regimen while on the wait-list. For ethical reason, and to avoid dropouts, the participants' in this group were offered the same training as the exercise groups after the control period.

Procedure and time line

The total duration of the intervention was 16 weeks, including 1 week set aside to familiarize the subjects, 1 week of pre-testing, 13 weeks of training and 1 week of post-testing. At baseline, the first time participants came for familiarization to physical tests, they completed questionnaires assessing demographic variables and subjective vitality. In Week 2, after two familiarization sessions and baseline physical testing, need satisfaction was measured (e.g., McAuley et al., 2000). Because participants are non-blinded in exercise studies the baseline assessments were performed before randomization. During Week 7 of the intervention (after five weeks of training) all participants rated their vitality. The exercise groups also completed perceptions of need satisfaction and autonomy support from instructors. The subjective vitality questionnaire was mailed to the control group, but they did not complete the exercise-specific questionnaires and had no other interaction with instructors or other participants. All participants, including controls, completed the subjective vitality questionnaire at the intervention site 16 weeks after baseline (3–4 days after the 13-week training period). Participants in the three exercise groups also rated their need satisfaction and perceptions of autonomy support from instructors.

A total of 19 instructors were trained over two sessions in standardized techniques of enhancing the participants' needs for autonomy, competence and relatedness, following the guidelines suggested elsewhere (Edmunds, Ntoumanis, & Duda, 2007b; Mageau & Vallerand, 2003). This was done to ensure that the instructors behaved and communicated in a standardized manner across the different training groups. Within all three groups the instructors were trained to emphasize positive feedback, learning names, involving the participants, and to give a rationale for all exercises. Participants were also given choice to select their own warm-up routines in their exercise programmes. In addition, the endurance group could choose music for aerobics and whether they wanted stretching at the end of sessions. The functional group could regulate their rest-intervals and what sequence they preferred doing the exercises. Participants in the strength training group could choose amongst different abdominal and lower-back exercises finishing the program and they had more options for warm-up exercises.

Measures

At baseline, participant's body mass index, living status, educational level, and vigorous activity was assessed. Body mass index was calculated from data given by a dual energy X-ray absorptiometry (DXA) using a Lunar Prodigy densitometer (GE Medical Systems, Madison, WI). Vigorous activity was assessed by asking the participants to report number of hours of vigorous activity in the past week. Vigorous activity was defined as activities involving sweating and making them breathless, and only activities lasting >10 min continuously was reported. Participants answered on the following scale: 1 (none), 2 (<1 h), 3 (1–2 h), 4 (3–4 h) and 5 (>4 h).

Vitality was measured with the trait version of Ryan and Frederick's (1997) scale. Following the stem "How do you feel in general?" participants answered the 6-item version validated by Bostic, Rubio, and Hood (2000). This scale has shown acceptable test-retest reliability (Ryan & Frederick, 1997), and indicated good alpha reliability (.82) among elderly in a nursing home (Kasser & Ryan, 1999). In the present study the alpha values were .91 (baseline), .92 (Week 7) and .93 (Week 16), respectively.

Psychological Need Satisfaction was assessed with the scale developed for the exercise domain by Vlachopoulos and Michailidou (BPNES; 2006). The participants responded to 12 statements, four each tapping the need for autonomy, competence and relatedness. The scale is validated on a Greek sample ranging from 18 to 64 years (Vlachopoulos & Michailidou, 2006), and was translated to Norwegian following the procedures described in Beaton, Bombardier, Guillemin, and Ferraz (2000). All subscales indicated acceptable alpha reliability with .78–.83 for autonomy, .78 to .84 for competence and .82 to .88 for relatedness.

Perceived Autonomy Support was measured with a short version of the 15-item Health Care Climate Questionnaire (HCCQ; Williams, Grow, Freedman, Ryan, & Deci, 1996). A short 6-item scale which has previously shown good reliability in exercise settings (Edmunds et al., 2007a) was selected to reduce number of items in the questionnaires. The full HCCQ taps the three socio-contextual dimensions of a need supporting environment: perceptions of autonomy support, involvement and structure (Markland & Tobin, 2010). The short version is slightly favoring the autonomy support dimension (three out of six items), therefore two items from the full version were added (e.g., "I feel a lot of trust in my instructor" and "I feel that the instructor cares about me as a person") to balance the scale out in terms of involvement and structure. As with previous studies (Markland & Tobin, 2010; Williams et al., 1996), the eight items yielded a single factor in the factor analysis (Week 16; maximum likelihood extraction with varimax rotation; factor loadings from .73 to .83 and 59.6% explained). Alpha reliability was .90 at Week 7 and .91 at Week 16.

In all questionnaires participants responded to the statements on a 7-point Likert-scale ranging from 1 (*not true at all*) to 7 (*very true*). The participants' mean score on the items in each scale was used in the analyses.

Statistical analysis

The present study was designed originally to have power to detect an effect of 0.5 standard deviations on the psychological outcomes with a sample size of 27 in each group. Subsequently we used a new way to evaluate the clinical importance of the results by making probabilistic magnitude-based inferences about the effects, rather than null-hypothesis significance testing (Hopkins, Marshall, Batterham, & Hanin, 2009). The *p*-value of a significance test is related to the likelihood that the true (large-sample) effect is null, but it has no practical interpretation. The new approach is based on

probabilities that the true effect is substantial in a positive and negative sense, and it gives decisive outcomes with smaller samples. Final sample size was about 30 participants in each group, similar to those in previous studies investigating relations between exercise and well-being (Cassilhas et al., 2007; DeVreede et al., 2007), and need satisfaction and well-being (Edmunds et al., 2008).

All data were analyzed with SPSS (version 15.0; Chicago, Illinois). The small proportion of missing items in the psychometric scales (<2%) appeared random; these items were therefore replaced using a general linear model combining main effects of items and subject (Roth, Switzer, & Switzer, 1999). Subjects responding to less than 50% of the items in each scale were omitted from analyses (Ware, Kosinski, & Dewey, 2000).

The possibility that the dropouts represented a population different from that of the completers was addressed with inferential comparisons using the unequal-variances *t*-test and the chi-squared test for means and proportions respectively. Inferences were based on the assumption of the normality of sampling distribution of the differences. Magnitudes of the differences between groups at baseline were assessed, but inferential comparisons here were considered inappropriate: any difference between the groups is real as far as imbalance in the assignment is concerned.²

The linear mixed model procedure was used to examine the effects of the four treatment groups on vitality. Mixed modeling was adopted to properly account for non-uniformity arising from individual responses in the different groups (Field, 2009; Hopkins et al., 2009). Mixed modeling consists of fixed effects (to estimate the mean effects of the treatments and the covariates) and random effects (to estimate standard deviations representing the individual responses). The covariates were moderators (subject characteristics that account for individual responses to the treatments) or mediators (variables that change and account for the mean effects of the treatments). The effects of the treatments were adjusted to the overall mean value of a potential moderator to eliminate the effects of any differences between group mean values of the moderator. A potential mediator was included as a change score in the model, because the resulting adjusted effects of the treatments are independent of the mediator (i.e., the effect when the mean change of the mediator is zero).

The predictors in the models were a nominal effect for treatment groups, linear effects for baseline vitality and perceived autonomy support (moderators), and linear effects for change in the three needs (mediators, with a separate model for each need). Each treatment group were dummy-coded to represent the presence (1) or absence (0) of a treatment (e.g., 1 for receiving endurance training and 0 for not receiving endurance training). The dummy-variables were included in the model as fixed effects to represent the absence or presence of a condition and as random effects to estimate additional variance representing individual responses. To allow for different individual responses, the treatments with largest error represented random effects and the group with the smallest error represented the residual. The moderators (autonomy support and baseline vitality) were rescaled to give

² Adjusting for baseline differences is always considered important. In the present study there were small differences (10–30% difference) on a few baseline values, but we could not adjust for too many covariates because of the sample size within each group (loss of *df*), and random relations may occur. Gender was not adjusted for in any of the models, owing to the low number of males within the groups, and because the distribution of gender was reasonably similar to that of the population for this age group in Norway (Statistics Norway, 2011). In addition, no gender differences on the exercise – well-being relationship has been found (Netzer et al., 2005), and no gender difference in the perceived need satisfaction and well-being relation has been observed among younger participants (Adie et al., 2008; Vlachopoulos & Karavani, 2009; Wilson et al., 2009).

a mean value of zero, while absolute change scores were used for the mediators (needs). The moderators were rescaled to ease the interpretation of the coefficients in the model provided by SPSS. A potential mediator was included in the model as a change score without rescaling, because the reduction in the treatment effect on the dependent variable relative to the model without the mediator is the effect of the treatment explained by the mediator. In Baron and Kenny's (1986) terms, a full mediation would reduce the treatment effect to a trivial value (<0.2), whereas a partial mediation would be a smaller but substantial reduction in the treatment effect.

Modeling was done in the following sequence for both short- (0–7 weeks) and long term effects (0–16 weeks). First, the effect of different types of exercise on vitality was estimated with adjustment for baseline vitality by interacting baseline vitality with treatment group (Model 1). Second, the effect of perceived autonomy support was examined by adding the interaction of perceived autonomy support and each of the three exercise groups to Model 1 (Model 2). Third, to estimate the effect of the proposed mediators within the exercise groups, perceptions of autonomy support was taken out of Model 2, and change in each of the three needs was included separately as an interaction with the three exercise groups (Models 3–5). Fourth, to investigate whether perceptions of autonomy support modified the effects of need satisfaction on vitality, we created an interaction term between autonomy support and change in each need within each exercise group. The term was added to a model already adjusting for baseline vitality, perceived autonomy support and need satisfaction (Model 6).

All data are presented as standardized effects with confidence limits, which were estimated with the standard deviation of the dependent variable across all analyzed subjects at baseline. The magnitude of the effect of a covariate on the dependent variable was evaluated as a difference of two standard deviations of the covariate to represent the difference between those high and low on the variable (Hopkins et al., 2009; Wiedemann, Schuz, Sniehotka, Scholz, & Schwarzer, 2009). Magnitude of all standardized effects was evaluated with a modification of Cohen's (1992) scale that aligns standardized effects with the corresponding point bi-serial correlations (Hopkins et al., 2009; Rosnow & Rosenthal, 1996): <0.2 , trivial; 0.2 – 0.6 , small; 0.6 – 1.2 , moderate; >1.2 , large. Magnitudes of baseline differences in proportions between groups were evaluated using a related scale: $<10\%$, trivial; 10 – 30% , small; 30 – 50% , moderate (Hopkins et al., 2009).

To make clinical inferences about true values of effects in the population studied, the uncertainties in the effects were expressed as probabilities of harm or benefit in relation to the smallest substantial effect (± 0.2) (Cohen, 1992; Hopkins, 2007; Hopkins et al., 2009). Effect of a treatment was deemed unclear if there was too much risk of harm when the chance of benefit was sufficiently high to warrant use of the treatment. For this purpose we have used a threshold of 66 for the odds ratio of benefit to harm (Hopkins et al., 2009); the ratio that corresponds to the limiting or definitive case of an effect that is almost certainly not harmful ($<0.5\%$ risk of harm) and possibly beneficial ($>25\%$ chance of benefit). All clear effects were evaluated probabilistically to communicate the chance of the effect being trivial, beneficial or harmful with the following scale; 25 – 75% (possibly), 75 – 95% (likely), 95 – 99.5% (very likely), $>99.5\%$ (most likely) (Hopkins, 2007). Magnitudes of covariates were evaluated mechanistically: if the confidence interval overlapped substantial positive and negative values (0.2 and -0.2), the effect was deemed unclear, and was otherwise evaluated probabilistically as described above. A level of 99% was chosen for confidence intervals to reduce the inflation of the overall error rate arising from the large number of mechanistic inferences (Hopkins et al., 2009).

Results

Descriptive statistics

Of the 138 participants at baseline, 91% were active at Week 7 ($n = 125$, $M = 74.3$ years, $SD = 4.5$, 68% females) and 86% ($n = 118$, $M = 74.3$ years, $SD = 4.6$, 68% females) completed the 16-week intervention. Table 1 shows the group characteristics for those measured at Week 7 and the baseline characteristics of those not completing at Week 16. Small baseline differences between groups in gender, living alone, education, vigorous activity and vitality were observed; other differences were trivial. Average training attendance was high (range: 50–100%), with no substantial differences between groups.

There were some small to moderate differences at baseline between the 20 participants who dropped out compared to those 118 who completed the trial. The dropouts reported lower education, vigorous activity, autonomy, competence and vitality (Table 1). Considering the low dropout rate of only 14 participants in the exercise groups at Week 16 (14% of the participants randomized to

Table 1
Group characteristics of participants who continued to Week 7.

	Endurance ($n = 31$)	Functional ($n = 27$)	Strength ($n = 31$)	Control ($n = 36$)	Dropouts ($n = 20$) ^b
Age (y)	73.9 \pm 3.6	73.2 \pm 3.6	75.0 \pm 5.9	74.8 \pm 4.3	74.0 \pm 3.9 [?]
Body mass index (kg m^{-2})	26.2 \pm 3.7	25.9 \pm 3.8	26.0 \pm 4.3	26.7 \pm 3.6	27.3 \pm 4.7 [?]
Females (%)	71	59	68	72	70 [?]
Living alone (%)	58	41	52	58	60 [?]
College education (%)	36	41	61	39	25**
Vigorous activity ^a (%)	13	7	13	3	0 [?]
Vitality at baseline	5.2 \pm 1.3	5.1 \pm 1.2	4.6 \pm 1.1	4.8 \pm 1.2	4.1 \pm 1.3***
Autonomy at baseline	5.5 \pm 1.0	5.6 \pm 0.8	5.2 \pm 1.0	–	4.9 \pm 1.1**
Competence at baseline	5.3 \pm 0.9	5.5 \pm 0.8	5.1 \pm 0.8	–	4.7 \pm 1.1**
Relatedness at baseline	6.1 \pm 0.8	6.1 \pm 0.9	5.6 \pm 1.1	–	5.7 \pm 1.1 [?]
PAS at Week 7	5.9 \pm 0.8	6.2 \pm 0.9	6.1 \pm 0.8	–	–
PAS at Week 16	6.1 \pm 0.9	6.3 \pm 0.6	6.4 \pm 0.6	–	–
Training attendance Week 3–7 (%)	86 \pm 13	85 \pm 14	94 \pm 8	–	–
Training attendance Week 3–16 (%)	87 \pm 10	84 \pm 13	92 \pm 6	–	–

Note. Data are mean \pm SD or proportion (%).

Potential range for all psychometrics: 1 to 7.

α , Cronbach's alpha; PAS, perceived autonomy support.

^a Proportion with self-reported vigorous physical activity >2 h wk^{-1} .

^b Substantial difference ($ES > .20$, proportion $>10\%$) from completers ($n = 118$): * possible, ** likely, *** very likely, ? unclear.

exercise), and assuming the dropouts had the same response as the controls, an intention-to-treat analysis with dropouts given the values of control group would give at most a 14% lower net effect of the treatments.

In general small to moderate changes in the exercise groups throughout the trial in vitality and need satisfaction were observed (Table 2).

Mixed model analyses

Results from the various models estimating the effects on the different types of training on vitality and the effects of covariates are shown in Table 3 (Baseline to Week 7) and Table 4 (baseline to Week 16). Model 1 shows the effect of the different types of exercise relative to controls while adjusting for baseline vitality. Model 1 is the reference model for evaluating the effects of the treatments when adjusting for the moderating effect of perceived autonomy support (Model 2) and the mediating effect of change in need satisfaction (Models 3–5). The reduction in vitality in Models 3–5 (compared to Model 1), indicates how much the mediator explains the effect of treatment on vitality. Effects of the covariate of interest are shown below the vitality effects in each model. Of the other subject characteristics that showed substantial differences at baseline, only vigorous activity was considered a possible moderator of the exercise effect on vitality: when included in the model, vigorous activity had trivial effects on changes in vitality within groups. Thus, vigorous activity was not included as a covariate in any model.

Short term effects of exercise, perceived autonomy support and need satisfaction

From baseline to Week 7, training had clear effects on changes in vitality (Table 3). Endurance training had a moderate effect, while the functional and strength training had small effects on vitality compared to controls (Model 1). In addition, the effects of endurance and functional training were small and likely beneficial compared to strength training ($ES = .49$, 99% confidence limits $\pm .52$ and $ES = .33$, $\pm .45$, respectively). Functional training had the most uniform response as indicated by the standard deviations of change in vitality (Table 2). The trivial-small negative effects of baseline vitality in Model 1 are consistent with greater effects of the treatments for participants with lower vitality initially.

Adjusting for perceptions of autonomy support made little difference to the overall treatment effects on vitality (Table 3; Model 1 vs Model 2). Nevertheless, the moderating effect of perceived autonomy support on vitality was clear in endurance

Table 2
Changes in vitality and satisfaction of the need for autonomy, competence and relatedness in each group.

	Group	Change at Week 7 (n = 125)	Change at Week 16 (n = 118)
Vitality	Endurance	0.57 ± 1.01	0.38 ± 0.81
	Functional	0.48 ± 0.64	0.21 ± 0.59
	Strength	0.19 ± 0.94	0.29 ± 0.69
	Control	-0.12 ± 0.71	0.17 ± 0.64
Autonomy	Endurance	0.31 ± 1.01	0.15 ± 1.16
	Functional	0.24 ± 0.80	0.10 ± 0.79
	Strength	0.15 ± 1.27	0.31 ± 1.15
Competence	Endurance	0.42 ± 0.87	0.36 ± 1.02
	Functional	0.45 ± 0.66	0.31 ± 0.66
	Strength	0.53 ± 0.94	0.81 ± 0.84
Relatedness	Endurance	0.31 ± 1.11	0.30 ± 0.98
	Functional	0.38 ± 0.67	0.40 ± 0.72
	Strength	0.77 ± 1.04	0.99 ± 0.96

Note. Data are mean ± SD. Potential range of change is -6 to +6.

training and thereby helped explain individual responses arising from the training: the effect of .66 indicates a moderately higher change in vitality for those with high (+1 SD) vs low (-1 SD) perceptions of perceived autonomy support (standardized improvements in vitality of 1.10 and .44, respectively).

The effects of changes in need satisfaction were trivial, but unclear at short term in all three training groups (Table 3; Model 3–5). The only substantial reduction in the mediator models was when adjusting for change in competence in strength training (Table 3; Model 4). The effect of competence was small and unclear by itself, but the effect of strength training on vitality was reduced by .14, sufficient for the effect to become possibly trivial compared to controls (Model 1 vs Model 4).

At short term, the interaction between perceived autonomy support and relatedness were small and possibly negative in functional training (Table 3; Model 6). Fig. 1a illustrates the interaction and shows that among those with low relatedness (-1 SD), high perceived autonomy support (+1 SD) was beneficial for vitality ($ES = .74$), but not among those high in relatedness ($ES = .12$).

Long term effects of exercise, perceived autonomy support and need satisfaction

By Week 16, the short term increases in vitality were slightly reversed following endurance and functional training, and a small increase appeared in controls (see Table 2). Thus, the only substantial net effect at long term was for endurance training, while it was possibly trivial for the other two groups (Table 4; Model 1). Endurance training was also possibly beneficial compared to functional and strength training ($ES = .19$, $\pm .42$ and $ES = .18$, $\pm .36$, respectively). Note that the within-group changes were small and possibly beneficial for functional ($ES = .22$, $\pm .20$) and strength training ($ES = .21$, $\pm .30$). The functional training still had the least individual variations in responses to the treatment (Table 2), and the only substantial negative effect of baseline vitality was observed in controls (Table 4; Model 1).

In contrast to the short term findings, the effect of perceived autonomy support was trivial and unclear with endurance training at long term, while the effect was clear with functional training (Table 4; Model 2). The moderating effect of perceived autonomy support was small and indicated enhanced vitality for those with a high (+1 SD) perception of autonomy support ($ES = .20$) versus low (-1 SD) autonomy support ($ES = -.02$).

At long term, competence was a clear mediator of the effect of functional and strength training on vitality. Comparing Model 1 (Table 4) with the mediator model (Model 4) shows that competence has accounted for a reduction of .18 in vitality following strength training, which is close to a substantial reduction (0.2). When competence was included, strength training became possibly harmful compared to control. Competence accounted for a smaller amount of the effect in functional training and the effect on vitality was reduced by .07 (Table 4; Model 1 vs Model 4). Note that overall changes in vitality appear trivial in functional and strength training (Model 1) because these are net effects (compared to control).

The only clear interaction effect at long term was for autonomy support and change in competence in endurance training (Table 4; Model 6). Fig. 1b illustrates that the effect of competence on vitality was moderate for those with high perceptions of autonomy support ($ES = .83$), compared to a trivial effect for those with low perceptions of autonomy support ($ES = -.03$).

Discussion

We aimed to investigate effects of different types of exercise on short term and long term changes in vitality among older adults.

Table 3

Net standardized effects of training on vitality (training minus control) from baseline to Week 7 derived from models that included adjustment for covariates; also shown are standardized effects of main covariates on vitality within each group.^a

Standardized effects of treatments compared to control (ES; ±99% CL)						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Endurance	.70, ±.44 ^{****}	.77, ±.42 ^{****}	.71, ±.46 ^{****}	.69, ±.47 ^{****}	.67, ±.47 ^{****}	.74, ±.47 ^{****}
Functional	.54, ±.36 ^{***}	.53, ±.36 ^{***}	.52, ±.37 ^{***}	.47, ±.39 ^{***}	.52, ±.39 ^{***}	.54, ±.39 ^{***}
Strength	.21, ±.47 [†]	.24, ±.48 [†]	.22, ±.48 [†]	.07, ±.51 ⁰	.20, ±.57 [†]	.23, ±.58 [†]
Standardized effects of main covariates in each model (ES; ±99% CL)						
	Vitality	PAS	ΔAutonomy	ΔCompetence	ΔRelatedness	PAS [†] ΔRelatedness
Endurance	-.46, ±.51 ^{††}	.66, ±.66 ^{**}	-.06, ±.72 [†]	.05, ±.74 [†]	.15, ±.75 [†]	.28, ±.73 [†]
Functional	-.26, ±.44 [†]	.16, ±.51 [†]	.12, ±.51 [†]	.21, ±.50 [†]	.06, ±.52 [†]	-.42, ±.61 [†]
Strength	-.19, ±.60 [†]	-.27, ±.82 [†]	.08, ±.83 [†]	.51, ±.77 [†]	.01, ±.79 [†]	.32, ±1.04 [†]
Control	-.09, ±.34 [†]	—	—	—	—	—

Note. Data are standardized effects (ES) and 99% confidence limits (CL) for subjects assessed at baseline and Week 7 (n = 125). Baseline SD of the dependent used for standardizing = 1.2.

Model 1: adjustment for baseline vitality.

Model 2: adjustment for baseline vitality and perceived autonomy support (PAS) at Week 7.

Models 3–5: adjustment for baseline vitality and zero change (Δ) in autonomy, competence and relatedness, respectively.

Model 6: adjustment for baseline vitality, perceived autonomy support, zero change (Δ) in relatedness, and the interaction between perceived autonomy support and Δrelatedness, respectively.

Effects of covariates are shown for 2 SD of the covariate.

Explanation of superscripts denoting probabilistic inferences: * possibly beneficial/positive, ** likely beneficial/positive, *** very likely beneficial/positive, **** most likely beneficial/positive, † possibly harmful/negative, †† likely harmful/negative, 0 possibly trivial, † unclear (more data needed).

^a Full analyses in original units and individual responses are available from the first author upon request 1.

Moreover, we examined whether perceived autonomy support and change in need satisfaction would help explain the effects of different types of exercise on changes in vitality. Endurance, functional and strength training improved older adults' feelings of vitality, with largest effects for endurance training. Perceptions of autonomy support moderated the effect of endurance training on vitality at short term, and of functional training at long term. There were no clear mediations at short term, and only competence mediated the effect of functional and strength training at long term. When the potentially modifying effects of autonomy support were included in the analyses of meditation, two clear interaction terms emerged: at short term the lower the autonomy support, the better relatedness explained the effects of functional training on vitality, while at long term autonomy support facilitated competence as a mediator in the effects of endurance training on vitality.

Effects of exercise on change in vitality

All three types of training were beneficial at short term, and largest effects were found in endurance training. At long term, endurance was the only group with beneficial effects, and was also

possibly beneficial compared to functional and strength training. Thus, an activity like walking, which most older adults do (Rhodes et al., 1999), is particularly useful for increasing vitality.

The small to moderate short term effects on vitality were reduced at long term. The lack of substantial findings at long term were likely due not only to a reduced effect in the exercise groups (although still beneficial), but also increased vitality in the controls. It could well be that the exercise participants were disappointed that the intervention was over, while the controls experience a boost in vitality from anticipating the start of their program in the subsequent cycle. Many trials measure change in indices of well-being only at the end of the treatment period, so the anticipatory effect in the controls may help explain why there are only small or trivial effects on well-being outcomes (e.g., DeVreede et al., 2007). The largest effects at short term are in accordance with previous findings (Arent et al., 2000; Netz et al., 2005), and our results point toward the importance of measuring vitality at several time-points during a trial. In addition, those low in vitality at baseline benefited most from the exercise at short term. This finding is consistent with the more general opinion that less effects of exercise on indices of well-being can be expected in already healthy seniors (Oken et al.,

Table 4

Net standardized effects of training on vitality (training minus control) from baseline to Week 16 derived from models that included adjustment for covariates; also shown are standardized effects of main covariates on vitality within each group.

Standardized effects of treatments compared to control (ES; ±99% CL)						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Endurance	.27, ±.38 [†]	.29, ±.39 [†]	.28, ±.38 [†]	.27, ±.39 [†]	.27, ±.41 [†]	.22, ±.40 [†]
Functional	.09, ±.30 ⁰	.09, ±.29 ⁰	.09, ±.30 ⁰	.02, ±.30 ⁰	.10, ±.32 ⁰	.01, ±.31 ⁰
Strength	.08, ±.38 ⁰	.12, ±.37 [†]	.07, ±.38 ⁰	-.10, ±.45 [†]	.02, ±.49 ⁰	-.07, ±.50 ⁰
Standardized effects of main covariates in each model (ES; ±99% CL)						
	Vitality	PAS	ΔAutonomy	ΔCompetence	ΔRelatedness	PAS [†] ΔCompetence
Endurance	-.15, ±.43 [†]	.06, ±.73 [†]	.20, ±.65 [†]	.17, ±.72 [†]	.04, ±.67 [†]	.51, ±.62 [†]
Functional	-.18, ±.35 ⁰	.23, ±.40 [†]	.07, ±.41 [†]	.31, ±.38 ^{**}	-.01, ±.42 [†]	.01, ±.45 [†]
Strength	.05, ±.51 [†]	-.34, ±.59 [†]	.27, ±.62 [†]	.43, ±.58 ^{**}	.12, ±.62 [†]	-.02, ±1.03 [†]
Control	-.24, ±.27 [†]	—	—	—	—	—

Note. Data are standardized effects (ES) and 99% confidence limits (CL) for subjects assessed at baseline and Week 16 (n = 118).

Model 6: adjustment for baseline vitality, perceived autonomy support at Wk 16 (PAS), zero change (Δ) in competence and the interaction between perceived autonomy support and Δcompetence, respectively.

See Table 3 for explanation of other models and superscripts.

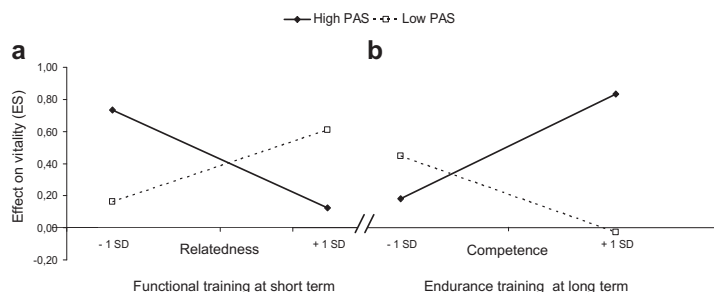


Fig. 1. Illustration of the effect of the interaction between perceived autonomy support and change in social relatedness in functional training at short term (a), and between perceived autonomy support and change in competence in endurance training at long term (b).

2006; Rejeski & Mihalko, 2001). Ironically, the dropouts in this study might have had the greatest benefits of exercise, considering their lower baseline vitality.

The differences observed between treatments at short term and at long term, may be explained by differences in training intensity. For example, the high-intensity strength training could have drained some of the participants' feelings of energy throughout the trial. However, only this training group increased their vitality from Week 7 to Week 16, whereas the endurance and functional training groups (moderate-intensity) decreased their vitality. Previous studies comparing high- and moderate-intensity strength training are not consistent in terms of energy/vitality as an outcome (e.g., Cassilhas et al., 2007; Tsutsumi et al., 1998). It may be that moderate-intensity works better in the beginning of a program, while high intensity is positive when participants accommodate to the intensity. It has been suggested that effects of training intensity on indices of well-being depend on the participant's initial health status (Ekkekakis & Petruzzello, 1999), because some participants find the intensity adequate, while others find it too high. In the present study the participants were allocated based on objective assessments of baseline physical capacity. In addition, we controlled for participants pre-intervention activity level in the preliminary analyses and the effects were trivial. Hence, the different changes in vitality between groups are unlikely due to the participants' initial fitness. A possible explanation is whether participants perceive that their training intensity is self-selected or controlled by the instructor (Vazou-Ekkekakis & Ekkekakis, 2009). This justification is consistent with the smaller standard deviation of the change in vitality observed in functional training which indicates that more people tended to go in the same direction compared to the two other treatments. In functional training participants could regulate their own intensity to a larger degree, and a more uniform response on vitality was observed.

In contrast to our findings of generally beneficial effects, Netz et al. (2005) indicated lower effect of exercise on energy/vitality measures compared with other measures of well-being (e.g., positive affect, negative affect, depression). Their finding may point toward the difficulty in comparing studies involving different training protocols and measures of vitality. Our results indicate that the vitality scale developed by Ryan and Frederick (1997) is sensitive to change in relation to exercise among healthy older adults.

The moderating effects of perceived autonomy support

There was a moderate difference in vitality between those high and low in perceptions of autonomy support in endurance training at short term. Improvements in walking capacity may be difficult to notice in the beginning of a program among already well-

functioning older adults. Therefore, aspects of autonomy support like informational feedback appear to be important for effects on vitality when activities like hiking and Nordic walking are adopted. At long term, the moderating effect of perceived autonomy support became trivial for endurance, but small for functional training. Thus, autonomy support appears to be more important at the end of a program of functional training when the decrease in competence from Week 7 to Week 16 indicated a stagnation of initial progress.

A moderator explains individual responses (standard deviation of change scores), but the lack of a clear moderating effect of autonomy support in strength training cannot be ascribed to less individual responses in perceptions of autonomy support and vitality in the strength group, because the standard deviation were similar to those in the other groups. One reason for the lack of a moderating effects of autonomy support in strength training could be that the strength training was perceived over-structured by participants, leaving little room for perceptions of autonomy support or involvement from instructors (Deci & Ryan, 1991). However, the strength group increased their need satisfaction more than the other groups from Week 7 to Week 16. Other aspects of the exercise context could be more central in strength training and perhaps the observable progress in loads, the challenge in the new program and the adaptation to the intensity account for the change in vitality in this group.

Mediating effects of need satisfaction

According to SDT all three needs are important for people's well-being, but their relative impact may depend on contextual factors (Deci & Ryan, 2000; Ryan & LaGuardia, 2000). It has been suggested that perception of competence is particularly important for well-being outcomes in exercise (Edmunds et al., 2007b), and among younger exercise participants competence had the strongest relation to well-being (Adie et al., 2008; Vlachopoulos & Karavani, 2009; Wilson et al., 2006, 2009). Our results indicate a similar trend among older adults and only the change in need for competence had clear effects on change in vitality.

The mediating effects of competence were heading in the right direction at short term but were only clear at long term in functional and strength training, possibly reflecting development of competence in some participants. Ryan and Frederick (1997) proposed that vitality should be more evident when bodily functions are effective, and Adie et al. (2008) suggested that the direct performance information from the exercise could be particularly important for older athletes. Thus, the positive effects of competence in functional and strength training, relative to endurance training, may be because progress was apparent to the participants'

in these two groups through the increases in training loads. The awareness of progress could have represented mastery experiences that increased perceptions of competence and in turn vitality (Arent et al., 2000). Thus, fostering competence by making the protocol adequately challenging and ensuring that participants manage the exercises seems important. In addition, the endurance protocol consisted of three different types of endurance training. Although all three were group-based and instructor led, this may have resulted in both positive and negative perceptions of the exercise context for some participants. As a result their perception of need satisfaction did not explain much of the change in vitality. Future studies should try to nurture the perception of competence directly also within endurance training, perhaps by using objective indicators of progress (e.g., heart-rate monitors).

Autonomy had the greatest standard deviations of the change scores compared to competence and relatedness. This indicates that people varied more in their responses concerning autonomy, and effects on vitality were small and unclear. Despite some options for choice in the protocols, the instrumentality of the structured exercise regime may have dampened the effects of exercise on autonomy and of autonomy on vitality (Wilson, Rodgers, Blanchard, & Gessell, 2003). In addition, satisfying all participants' need for autonomy in a group setting can be difficult, and some participants may have felt controlled (by the instructor or the other participants). Moreover, the autonomy items reflects the participants' personal preferences with the type of exercise, and the randomization procedures may have decreased feelings of autonomy for those who wanted to be in another training group. A group where participants are given a choice of mode would be preferable in future studies.

It has been proposed that the social element of exercise is particularly important for older adults' well-being (McAuley et al., 2000). Relatedness changed substantially (e.g., with strength training), but these changes had trivial and unclear relations to changes in vitality during the trial. Other indices of well-being could be more strongly affected by social relatedness. For example, McAuley et al. (2000) found positive effects on life satisfaction from the social interactions appearing in exercise, but not on happiness. Another explanation for the trivial effect of relatedness on vitality could be that the new acquaintances emerging during the study represent lower quality relationships and that frequency of contacts is less important (Carstensen, 1998; Kasser & Ryan, 1999; Penninx et al., 1998; Ryan & Deci, 2001). Finally, although participants had not been exercising regularly the past 6 months before commencement, they were relatively fit and socially active (Solberg et al., *in press*). This is also observed in previous studies using similar recruitment strategies (DeVreede et al., 2007; Oken et al., 2006). The effect of relatedness would probably be greater with older adults whose social life would be additionally enriched by exercise.

In general there were few clear effects of change in the three needs on vitality, and we suggest several explanations. First, the BPNEs was administered two weeks after measurement of baseline vitality to allow participants to relate their responses to the protocols. Consequently, there may have been considerable changes in vitality within these two weeks. Second, the timing of measuring needs here may have been too early for participants to acquire a stable perception of the social environment (Reinboth & Duda, 2006). Third, because participants had high baseline scores on vitality and need satisfaction, ceiling effects may have limited the extent to which they could explain vitality. Fourth, there was almost certainly attenuation of the mediating effect arising from random error in change scores (Fan, 2003). Furthermore, other mechanisms may have been more important. For example, the endurance training had biggest effects yet change in the three

needs explained little in vitality. The endurance group trained in natural outdoor surroundings twice a week, while the other groups exercised only indoors. Previous studies have suggested that training outdoors influences perceptions of vitality (Plante et al., 2006; Ryan et al., 2010).

Moderating effects of autonomy support on the mediators

Of the interaction terms tested, only two were clear. The negative interaction at short term in functional training indicate that among those with low perceptions of autonomy support from instructor a sense of relatedness and support from the group is particularly important for feelings of vitality. In contrast, when perception of autonomy support was high, relatedness explained little of the effect on vitality. This result support Edmunds et al. (2007a) which hypothesized that relatedness from other participants is extra important if autonomy support decrease. At long term, neither the change in competence or perceived autonomy support alone had any substantial influence on vitality in endurance training, but interaction analyses showed that competence was beneficial among those with high perceptions of autonomy support. Thus, the instructor could alter the effect of competence on vitality in endurance training. The positive feedback informing the participants about their progress and rationale given for the exercise seem essential for these older adults when performing training in which direct improvements may be less noticeable. There was also a trend toward small effects on vitality for the interaction between autonomy support and change in autonomy and relatedness. Hence, an autonomy supportive instructor may modify the effects of all three needs on vitality in endurance training.

Study limitations and future research

The present study was underpowered to make clear conclusions about trivial effects, and even some small effects were unclear. On the basis of our confidence intervals we would suggest a sample size of about 60 in each group in future studies investigating these aims. Further, although we had a low dropout rate, future exercise programs for the elderly should aim to reduce the dropouts, because it is the dropouts who are likely to benefit most. Future research should also endeavor to include measurement of the covariates in a control group. In the present study we did not measure the mechanisms in the control group because they did not perform any exercise. Hence, including a social control group not performing vigorous exercise (e.g., YOGA, flexibility) is warranted when investigating effects of social contextual variables on indicators of well-being. The only way to investigate the causal effects of autonomy support and need satisfaction would be to have two groups performing same type of training, with one group receiving autonomy support and the other not. The present study opted for investigating the effect of different training types and identifying mechanisms of the effect, but upcoming studies should consider such experimental design.

The present study focused on the socio-contextual variables (instructor and perceived need satisfaction) and their effects on vitality within different types of exercise, but also people's regulation of motivation has been shown to contribute to well-being within exercise (e.g., Edmunds et al., 2007a). Hence, future studies should also examine the effects of older adults' regulation of motivation within different types of exercise.

Conclusion

Exercise and especially outdoor endurance training is likely to increase older adults' subjective vitality. Further, the effects of

training were greater among those with high perceptions of autonomy support at short term in endurance, as well as among those in the functional training at long term. Need for competence mediated the effect of strength and functional training over the trial, while moderated-mediation analyses revealed that competence increased vitality only among those with high perceptions of autonomy support in endurance training. Study findings emphasize the importance of providing autonomy support and in particular satisfying the need for competence to enhance well-being among older adults in exercise.

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PAPER III

Linking exercise and causality orientations to change in well-being among older adults: does change in motivational variables play a role?

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Abstract

A self-determination theory process model of change in well-being was tested among older adults in a 16-week randomized exercise-trial ($n = 118$, $M = 74.3$ years, $SD = 4.6$, 68% females). The exercise intervention increased participants' autonomous motivation and perceived competence over the first 7 weeks. Moreover, autonomous orientation gave rise to perceived competence, while impersonal orientation was related to increased controlled motivation. Changes in motivational variables were positively related to changes in vitality over the trial, while change in controlled motivation was negatively related to changes in vitality and subjective well-being. Bootstrapping analyses supported an indirect exercise–vitality path through autonomous motivation and perceived competence, and an indirect autonomous orientation–vitality path through perceived competence.

Much of the research in gerontology deals with precursors of prolonged life and quality of life in the elderly, and a tremendous amount of research have investigated the effect of physical activity on these outcomes among older adults. The physiological benefits of physical activity are well documented (Nelson et al., 2007), and there is a general agreement as to the relation between physical activity and enhanced mental health in elderly (Arent, Landers, & Etnier, 2000; Netz, Wu, Becker, & Tenenbaum, 2005). Quality of life and well-being is “the difference between active living and just being alive” (Spirduso, Francis, & MacRae, 2005, p. 28), and thus one of the major outcomes in exercise trials among elderly. However, the results are not consistent and recent reviews have requested for theoretically driven research identifying the mediators and moderators of the exercise–well-being relation (Fox & Wilson, 2008; McAuley & Morris, 2007). Mediating and moderating mechanisms can inform about why and for whom an exercise intervention is effective (Fox & Wilson, 2008; McAuley & Morris, 2007; Rejeski & Mihalko, 2001), and a theory-based intervention paves the way for how to intervene on the mechanisms. Therefore, in the present study, we aimed to identify and test mediators and moderators of the relation between exercise and well-being through the self-determination theory (SDT) process model (Deci & Ryan, 2000; Williams et al.,

2006) with data from a randomized controlled exercise trial among older adults.

It has been suggested that both valuing and enjoying physical activity and self-efficacy could mediate the relation between exercise and well-being among older adults (Netz et al., 2005; Rejeski & Mihalko, 2001). The SDT process model of health behavior change includes autonomous motivation, which involves enjoyment and importance (e.g., value) for the activity, and perceived competence, which bears a similarity to the concept of self-efficacy (Deci & Ryan, 2000; Williams et al., 2006; Williams, McGregor, Zeldman, Freedman, & Deci, 2004). The SDT process model has generally been adapted to understand different behaviors (i.e., medical adherence, physical activity behavior), as well as mental health among patients with diabetes (Williams, Lynch, & Glasgow, 2007; Williams et al., 2009). Consequently, the model provides a framework for testing autonomous motivation and perceived competence as possible mediators of the exercise–well-being relationship among elderly. The SDT process model also includes peoples' causality orientations as a precursor of change in motivation and competence (Deci & Ryan, 1985; Williams, Grow, Freedman, Ryan, & Deci, 1996). Peoples' causality orientations, a relatively stable personality characteristic, may moderate of the effects of exercise on the proposed mediators.

Self-determination theory (Deci & Ryan, 2000) is concerned with understanding people's motivational regulation for behavior and its implications for their well-being. According to SDT, people's motivation can vary in its degree of self-determination, from autonomous to controlled regulation. Self-determined forms of regulated behavior should increase well-being, while the opposite is expected to result from forms of regulated behavior low in self-determination. People are considered autonomously regulated when they experience a sense of volition, joy, and personal endorsement of their behavior. When people feel pressured by interpersonal or internal forces, they are considered to pursue their behavior for controlled reasons (Williams, Freedman, & Deci, 1998). For example, when older adults do strength training because they understand the importance of maintaining their strength or value staying healthy, they are considered to be autonomously motivated. In contrast, if the elderly exercise because their physician or family wants them to or because they feel guilty about their physical shape, they are regarded as being controlled. SDT also holds that, in addition to being autonomously motivated, people must feel competent for optimal functioning and enhanced feelings of well-being (Deci & Ryan, 2000). According to Williams et al. (2006), people are perceived as competent "when they feel able to attain and control outcomes of their behaviour" (p. 9).

In the SDT process model of behavior change, both autonomous motivation and perceived competence is hypothesized to mediate the effect of the context on a variety of positive health outcomes (Deci & Ryan, 2000). In particular, a context characterized by autonomy support is considered to increase autonomous motivation and perceptions of competence (Deci & Ryan, 2000; Williams et al., 2004, 2006, 2009). Therefore, much attention is given to the effect of autonomy-supportive instructors, which includes acknowledging the participants' perspectives, being empathic and supportive, providing choice, and giving a meaningful rationale (Tessier, Sarrazin, & Ntoumanis, 2008; Williams et al., 2009). Previous studies have supported the model in terms of better glucose control (Williams et al., 1998), diabetes self-management (Williams et al., 2004), smoking cessation (Williams et al., 2006), dental care (Halvari & Halvari, 2006), medication adherence (Williams et al., 2009), and weight loss (Williams et al., 1996). To our knowledge, only two studies have included indicators of mental health when examining the SDT process model among diabetes patients. In both studies, change in perceived competence contributed to higher quality of life (Williams et al., 2009), and less diabetic distress and reduction in depression (Williams et al., 2007). Regulation of motivation was not included in the latter study. One experimental study has tested the SDT process model in the context of physical activity. The model was partially supported in that participants in an intensive autonomy-supportive condition compared to a brief

autonomy-supportive condition, reported higher levels of autonomous motivation at 6 weeks, which, in turn, were related to higher levels of physical activity at the end of the 13 weeks intervention (Fortier, Sweet, O'Sullivan, & Williams, 2007). However, the model has not been tested in relation to other indices of well-being nor among older adults in an exercise context.

In addition to an autonomy-supportive context, SDT holds that personality differences in terms of causality orientations can affect people's regulation of their behavior (Deci & Ryan, 1985, 2000). Three different causality orientations are suggested: the autonomous orientation, which involves a general regulation on the basis of interests and self-endorsed values; the control orientation, which involves a tendency toward controls and directives concerning how one should behave; and the impersonal orientation, which involves focusing on indicators of inefficacy and not behaving intentionally (Deci & Ryan, 1985, 2000). Williams et al. (1996) found that both autonomy support from staff and autonomous orientation predicted autonomous motivation for weight loss. Autonomous orientation has also been related to indicators of well-being and less self-handicapping (Deci & Ryan, 1985; Knee & Zuckerman, 1998). While people are assumed to hold all orientations to some degree, differences in strength of participants' causality orientations may affect the relation between exercise and well-being through autonomous motivation and perceived competence. Causality orientations are considered the least explored factors in SDT, especially within sport and exercise (Ryan & Deci, 2007; Wilson, Mack, & Grattan, 2008). Hence, the current study expands previous ones by including causality orientations when investigating relations between exercise and change in the motivational variables.

According to SDT, motivation is considered a developmental continuum and a progressive change with time might occur (Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003; Deci & Ryan, 2000). Mullan and Markland (1997) hypothesized a shift from controlled types of motivation to more autonomous motivation between adoption and adherence stages of exercise because exercise may not be intrinsically rewarding or interesting in the beginning. This shift in motivation has subsequently been observed in autonomous forms of motivation in longitudinal studies among younger participants (Wilson & Rodgers, 2008; Wilson, Rodgers, Blanchard, & Gessell, 2003). Therefore, it could well be an effect of exercise itself on motivation and perceived competence. Nevertheless, most studies within the exercise domain have been cross-sectional and included already active younger participants (Chatzisarantis et al., 2003). There has been a request for experimental and longitudinal studies based on the tenets of SDT within physical activity using other populations than students (Edmunds, Ntoumanis, & Duda, 2008; Wilson & Rodgers, 2004). Only

a few earlier SDT studies have focused on older adults in general, and it has been found that a sense of autonomy is important for autonomous motivation (O'Connor & Vallerand, 1994), in turn being important for the quality of leisure experience (Losier, Bourque, & Vallerand, 1993). More recently, Kasser and Ryan (1999) found that autonomy support from staff was positively related to feelings of autonomy, life satisfaction, and vitality among elderly living in a nursing home. Older adults may be at risk for losing their autonomy and competence compared to younger people. For example, multiple losses may lead to a decline in physical health and function (Kunzmann, Little, & Smith, 2000; Spirduso, Francis, & MacRae, 2005), which again could cause a decline in competence and autonomy by not being able to perform activities that one used to do (Heckhausen, 2005). These declines in autonomy and competence may again cause a decrease in well-being. Therefore, it seems especially important to investigate the effects of exercise on autonomous motivation and perceived competence, in addition to the effects of these variables on well-being. With the well-known importance of being physically active and possessing well-being in later life, it is surprising that there are so few studies that have investigated SDT's propositions among older adults within the exercise domain.

Well-being is generally considered a multidimensional phenomenon (Diener, 1984; Kunzmann et al., 2000; Netz et al., 2005; Spirduso et al., 2005). A plethora of well-being indices and measures can be observed in the literature, of which many have been constructed for use with clinical populations (Netz et al., 2005; Rejeski & Mihalko, 2001). One approach has been Diener's (1984) conception of subjective well-being (SWB), defined as the presence of high life satisfaction and positive affect and the absence of negative affect. This has been termed the hedonic view and often referred to as happiness (Ryan & Deci, 2001; Ryan, Huta, & Deci, 2008). In addition, SDT embraces an eudaimonic view on well-being, which focus on the process of living well and whether a person is fully functioning (Ryan & Deci, 2001; Ryan et al., 2008). The subjective vitality scale was developed within the frames of SDT as a measure of eudaimonic well-being (Ryan & Frederick, 1997). Research building upon SDT has typically adopted both the hedonic and eudaimonic approach as indicators of a person's well-being (Deci & Ryan, 2000; Edmunds, Ntoumanis, & Duda, 2007a; Ryan & Deci, 2001). However, the hedonic and eudaimonic perspectives may have different antecedents because some routes to short-term happiness may not lead to eudaimonia (Ryan & Deci, 2001; Ryan et al., 2008). For example, within the exercise domain, Edmunds et al. (2007a) found that intrinsic motivation (autonomous motivation) positively predicted positive affect, while introjection (controlled motivation) negatively predicted vitality. Nix, Ryan, Manly, and Deci (1999) found

that having success at a task while autonomously motivated enhanced vitality, whereas having success while being controlled did not, and that differences in motivation was not differentially related to positive affect. Therefore, we have included both indices of well-being when investigating the relations to motivational variables.

Based on the theory and research described, the following hypotheses were tested: The exercise group (relative to control) was expected to increase autonomous motivation and perceived competence from baseline to Week 7 (Hypothesis 1), which both, in turn, would increase participant's well-being over 16 weeks (Hypothesis 2). Further, changes in the motivational variables would mediate the link between exercise and changes in well-being (Hypothesis 3). In addition, we explored whether change in the motivational variables would mediate the relations between causality orientations and change in well-being; and whether the effects of exercise on changes in the hypothesized mediators were moderated by the participants' causality orientations.

Method

Study design and participants

Two-hundred eighty-four older adults were recruited through posters and newspaper advertisements to a 16-week randomized controlled exercise trail. Of these, 123 withdrew or were found ineligible in telephone screenings or in an informational meeting. Inclusion were men and women ≥ 70 years, living at home, sedentary (defined as maximum 1 structured exercise session per week the previous 6 months), that participation in exercise would not be expected to cause any physical harm, being able to read and speak Norwegian, and willingness to commit to the study. Exclusion criteria were myocardial infarction within the past 6 months, uncontrolled hypertension, bone mineral density in L2-L4 $< .84 \text{ g/cm}^2$, cognitive impairment (< 24 on the Mini Mental State Examination; Folstein, Folstein, & Mchugh, 1975), and use of corticosteroids the previous 6 months.

Another 12 participants were excluded after a medical screening, and additionally 11 withdrew from the study before baseline testing. Thus, 138 participants ($M = 74.2$ years, $SD = 4.5$, 68% females) were randomized to exercise or a control group (see Figure 1). All participants provided written informed consent prior to the tests. The study was approved by the Regional Ethics Committee of Southern Norway and the Norwegian Data Inspectorate.

The total duration of the intervention was 16 weeks, including 1 week set aside to familiarize with the physical tests, 1 week testing, 13 weeks training, and 1 week post-testing. At baseline (T_0), all participants completed questionnaires assessing demographic variables, causality

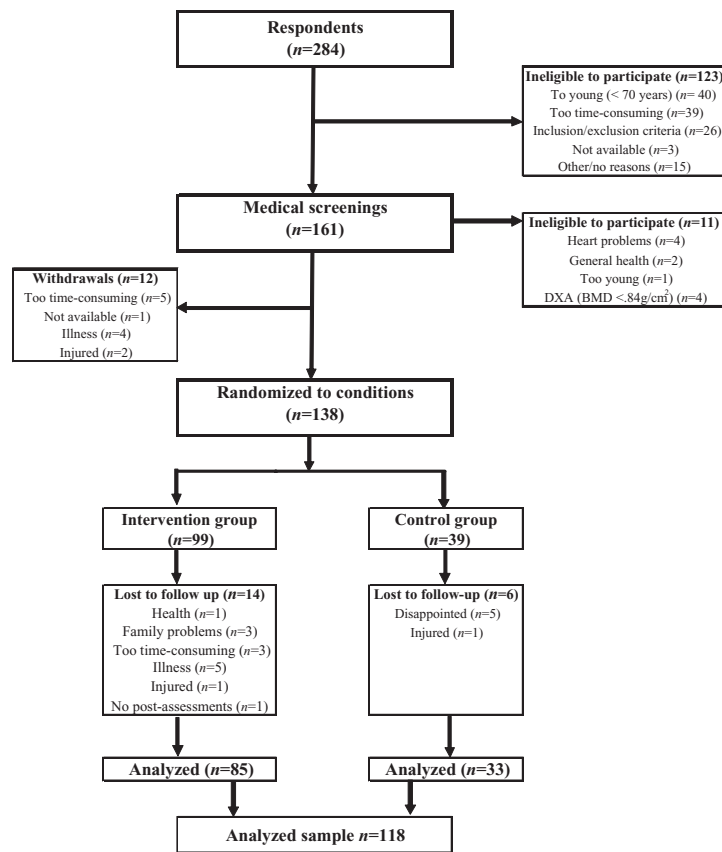


Figure 1 Flow chart (CONSORT recruitment and retention of participants).

orientations (Exercise Causality Orientations Scale [ECOS]; Rose, Markland, & Parfitt, 2001; and General Causality Orientations Scale [GCOS]; Deci & Ryan, 1985), perceived competence for exercise (Perceived Competence Scale [PCS]; Williams & Deci, 1996), motivation for exercise (Behavioural Regulation in Exercise Questionnaire [BREQ]; Mullan, Markland, & Ingledew, 1997), subjective well-being (Positive and Negative Affect Schedule [PANAS]; Watson, Clark, & Tellegen, 1988; and Satisfaction with Life Scale [SWLS]; Pavot & Diener, 1993) and subjective vitality (Subjective Vitality Scale [SVS]; Ryan & Frederick, 1997). All participants completed the PCS and BREQ again during Week 7 of the intervention (T_1).¹ The questionnaire package was mailed to

¹The reason for the 7-week assessment of the motivational variables was that some mediators might have a rapid initial response (Kraemer, Wilson, Fairburn, & Agras, 2002), and previous exercise interventions among elderly have indicated that self-efficacy variables change most in the first part of the intervention period (Netz et al., 2005). Most important, prior studies testing

the wait-list control group. Sixteen weeks after baseline (T_2) and about 1 week after the 13 weeks exercise trial, all participants completed the well-being scales at the intervention site.

Randomization procedures

In this trial, the eligible participants were originally randomized to three different exercise protocols (strength training, functional training, or aerobic training), but for the purpose of this study, all exercise groups were analyzed as

the SDT process model have measured motivation and perceived competence after 4 weeks of the intervention (Fortier et al., 2007; Williams et al., 2006). The training program started in week 3 (after familiarization and physical tests), and by assessing the mediators in Week 7 (after 4 weeks of exercise) the changes in motivation and competence could be compared to previous interventions.

one group (exercise condition). Participants were stratified according to gender, and their scores on several tests of physical function. Seven married couples and cohabitants were paired and drawn to different groups to ensure similarity among the groups and make it easier for them in terms of travelling.

Exercise condition (n = 99)

Participants in the exercise condition exercised three times per week for 13 weeks, and followed three different training protocols: strength training, functional training, or aerobic training. Each session lasted approximately 60 minutes, including a warm-up and a cool-down. There were one to two instructors present at the training sessions, and the participants exercised in groups of 10 to 15.

Wait-list control group (n = 39)

Participants in the control group were asked to continue their daily activities as before, and to not start any new training programs while on the wait-list. For ethical reasons, and to avoid dropouts, the participants were offered similar training as the exercise groups after the intervention period.

Training of instructors

Previous studies have shown that it is possible to educate practitioners to enhance their autonomy-supportive behavior (Edmunds et al., 2008; Williams et al., 2006). Thus, we carried out two training sessions for all instructors aiming to ensure that they acted in a standardized manner across the three exercise groups. The guidelines for the instructors were developed following the practical examples in the SDT literature (e.g., Edmunds, Ntoumanis, & Duda, 2007b; Mageau & Vallerand, 2003; Tessier et al., 2008; Wilson & Rodgers, 2007). In general, the instructors were trained to emphasize positive improvement-based feedback, involve the participants, learn their names, and to give a meaningful rationale for all exercises. Participants were also allowed to choose warm-up routines in their exercise programs.

Measures

Motivation

The participants completed a slightly upgraded version of the 15-item BREQ (Mullan et al., 1997). The scale taps the reasons people have for doing exercise, but some of the items did not fit the elderly with little or no experience from exercise. Thus, the wording in the stem was changed to "Why do you *want to* exercise?" and the word "regularly" was taken out of the identified items because many participants did not exercise regularly. In a pilot test, among 57 older exercisers,

one of the identified items from the original BREQ (i.e., "I get restless if I don't exercise regularly") loaded on the introjection subdimension in the factor analyses. This identified regulation subscale item was replaced by one item from the Treatment Self-Regulation Questionnaire (TSRQ; Williams et al., 1996; "It is important to me"). In addition, because borderline low Cronbach's alpha has been indicated on the introjected subscale among younger participants (Wilson et al., 2003), one item from the TSRQ introjected subscale was added (i.e., "I feel bad about myself for not exercising"). This ended in a final version with 16 items, four on each subdimension of regulation. The original BREQ have a 0 to 4 response scale (Mullan et al., 1997), but we adopted the 1 (*not true for me*) to 5 (*very true for me*) Likert scale validated by Wilson, Rodgers, and Fraser, (2002) to have similar responses to the scales throughout the questionnaire and thereby avoiding misunderstandings among the older participants.

The BREQ has been utilized in several exercise studies and shown acceptable psychometric properties (Wilson et al., 2002). In the present study, the scale loaded on three factors in the factor analyses, one autonomous (intrinsic and identified items), one introjected, and one reflecting external regulation, explaining 57.2% of the variance. In accord with Wilson et al. (2002), there was a high correlation between the intrinsic and identified regulations ($r = .69, p < .001$). Thus, we estimated an *autonomous motivation* variable of the averaged sum of the intrinsic and identified items, and a *controlled motivation* variable of the averaged sum of the introjected and external items (e.g., Williams et al., 2004). Cronbach's alpha for autonomous motivation was .89 at T_0 (baseline), and .92 at T_1 (7 weeks), and for controlled motivation .85 at T_0 , and .85 at T_1 .

Perceived competence

Perceived competence was measured with an exercise version of the 4-item PCS (Williams & Deci, 1996). Following the stem "How do you perceive your ability to be physically active", the participants responded on a 7-point Likert scale ranging from 1 (*not at all true*) to 7 (*very true*). Sample item: "I know how to be physically active". The averaged sum of the four items reflects perceived competence. The scale has been tested in a number of studies (Williams et al., 2004, 2006), and shown good psychometric properties within exercise (Fortier et al., 2007). In the current study, alphas of .91 (T_0) and .92 (T_1) was obtained.

Causality orientations

To tap individual differences in the participants' autonomous, controlled, or impersonal orientations, a combined measure with three vignettes from the ECOS (Rose et al., 2001), and four vignettes from the GCOS (Deci & Ryan, 1985) was used. There were two reasons for this: First, the

ECOS is a context-specific questionnaire especially constructed for exercise, but some items were not suited for participants with little or no experience with exercise. Second, the randomization procedures implying that the participant's were entered into predetermined exercise groups. Consequently, an item from ECOS like "During a discussion with an exercise counselor, he/she presents many options on the best way for you to achieve fitness and health benefits. It is likely that your first thought would be", would seem irrelevant. Items from ECOS and GCOS were thus selected due to their face validity and suitability for the relatively untrained participants. The vignettes from GCOS were made exercise specific, and all seven vignettes have three possible responses representing each of the three orientations. Example of a vignette (ECOS): "During an exercise session, how hard you are working out is likely to be governed by"; (1) "How you are feeling while exercising at the intensity you choose" (*autonomy orientation*); (2) "The intensity you have been told to exercise at" (*control orientation*); (3) "What everyone else around you are doing" (*impersonal orientation*). Each response is followed by a 7-point scale where the respondent rates the extent to which the response is characteristic for him or her ranging from 1 (*very unlikely*) to 7 (*very likely*). After removing two vignettes from the impersonal and controlled orientations and one from the autonomous orientation subscale, the variables indicated alpha values at .67, .65, and .77, respectively.

Well-being

To assess the participants eudaimonic well-being, the 6-item version of the SVS (Ryan & Frederick, 1997) validated by Bostic, Rubio, and Hood (2000) was used. Following the stem "How do you feel in general?" (example item: "I feel alive and vital") participants answered on a 7-point scale ranging from 1 (*not at all true*) to 7 (*very true*). Cronbach's alpha on the two measurement points were .91 (T_0), and .93 (T_2), respectively.

Hedonic well-being was measured with a short 12-item version of the PANAS (Watson et al., 1988), and the 5-item SWLS (Pavot & Diener, 1993). A SWB composite was computed by summing the average of life satisfaction (SWLS) and positive affect, and subtracting the average of negative affect (e.g., Brunstein, 1993). The SWB variable also indicated acceptable internal consistency, with alphas at .82 (T_0 and T_2). Both well-being indices have previously been found adequate among older adults (Kasser & Ryan, 1999; Kercher, 1992).

Data analyses

Initial power analyses indicated that 27 participants in each group were needed in order to detect half a standard

deviation difference in well-being between groups with 80% power. Additional power analyses indicated that over 50 were needed for the motivational variables. Thus, when accounting for 25% dropouts and to maintain power, we analyzed the three exercise groups as one group. In the present study, 28.3% (39) of the eligible participants (138) were randomized to the control group (Figure 1). Williams et al. (2006) randomized 30% of the participants to the control group, and this ratio was justified in terms of a greater expected effect of the intensive intervention.

Missing data were replaced using a regression equation estimating the missing value based on both the subjects' response on completed items in the scale and the value of the missing item generated from the sample data as recommended elsewhere (Roth, Switzer, & Switzer, 1999). Subjects with less than 50% of the items in a subscale completed were dismissed from analyses (Ware, Kosinski, & Dewey, 2000). Chi-square and t tests were used to compare those completing the intervention with dropouts for demographic variables and main variables in the study. Paired sample t tests were used to test the mean change in perceived competence, autonomous motivation, controlled motivation, SWB, and vitality. Independent sample t tests were used to examine the difference between the two groups. Because of the low sample size and numerous indicators in the model, the hypotheses and SDT process model were tested with correlations, multiple regressions, and bootstrapping analyses (Preacher & Hayes, 2008). According to Hu and Bentler (1999), structural equation modeling tends to over-reject true-population models under non-robustness conditions with small sample sizes ($n \leq 250$). There is two groups in the present study, hence the independent variable is a dichotomous one (exercise condition = 1, control group = 0). Bootstrapping is a nonparametric test and is considered especially favorable with dichotomous variables and small samples (Preacher & Hayes, 2008; Shrout & Bolger, 2002).

All change scores were calculated using the standardized residual scores in regression analyses, which seems to be the most appropriate because it corrects for the phenomenon of "regression to the mean" (Twisk & Proper, 2004). Data were analyzed using SPSS version 15.0 (SPSS Inc., Chicago, IL), and statistical significance was set at $p < .05$.

Results

Preliminary analyses

Of the 138 participants starting up at baseline, 125 remained involved after 7 weeks and 118 completed the 16-week intervention ($M = 74.3$ years, $SD = 4.6$, 68% females, Figure 1). This gives a total compliance of 85.5%, and average training attendance for the analyzed participants in the exercise group was high ($M = 86.7\%$, $SD = 11.5$, range: 50–100%).

Table 1 Descriptive Statistics

	Exercise (n = 85)	Controls (n = 33)	Dropouts (n = 20)
Characteristics			
Age (years)	74.1 ± 4.7	74.6 ± 4.5	74.0 ± 3.9
Females (%)	66	73	70
Living alone (%)	49	58	60
College education (%)	45	39	25
Occupation (%)	15	12	10
Smoking habits (%)			
Never	57	49	35
Former	34	42	50
Current	9	6	15
MMSE score (0-30)	29.2 ± 1.2	28.9 ± 1.4	28.6 ± 1.2
BMI (kg/m ²)	26.1 ± 3.9	26.4 ± 3.6	27.3 ± 4.7
Physical activity level (%)			
Low intensity >2 hours/week	48	55	20
High intensity >2 hours/week	12	3	0
Prevalent diseases (%)			
CVD	34	39	50
Diabetes	7	4	20
Osteoarthritis	18	29	10
Obstructive lung disease	10	4	9
Baseline variables			
Autonomous orientation (1-7)	5.4 ± 1.1	5.4 ± 1.2	5.3 ± 1.0
Controlled orientation (1-7)	3.3 ± 1.1	3.3 ± 0.9	3.9 ± 1.5
Impersonal orientation (1-7)	2.6 ± 1.2	2.8 ± 1.0	3.2 ± 1.6
Autonomous motivation (2-10)	8.4 ± 1.3 ^a	7.6 ± 1.8	8.0 ± 1.6
Controlled motivation (2-10)	4.8 ± 1.9	5.0 ± 1.7	5.8 ± 2.0
Perceived competence (1-7)	5.4 ± 1.2	5.3 ± 1.3	4.8 ± 1.1 ^b
Subjective vitality (1-7)	5.0 ± 1.2	4.9 ± 1.3	4.1 ± 1.3 ^b
Subjective well-being (-3 to 11)	6.5 ± 1.7	6.3 ± 2.0	5.3 ± 2.3

Note. Data presented as mean and standard deviation or percent.

BMI = body mass index; CVD = cardiovascular disease; MMSE = Mini Mental State Examination.

^aSignificantly different from controls, ^bsignificantly different from completers.

Effectiveness of randomization procedures

T tests indicated no significant differences between the exercise and control group for baseline scores on causality orientations, perceived competence, controlled motivation, SWB, or subjective vitality. However, participants in the exercise group reported significantly higher autonomous motivation at baseline ($t = 2.12$, standardized effect size [ES] = .44, $p < .05$).

Dropouts versus completers

Baseline scores indicated that dropouts had significantly lower vitality ($t = 2.71$, $p < .05$), and perceived competence ($t = 2.23$, $p < .05$) than the completers. The dropouts also had marginally lower SWB ($t = 1.99$, $p = .06$), and marginally higher controlled motivation ($t = -1.92$, $p = .06$). The dropouts resulted in a larger difference between the exercise and control group in baseline autonomous motivation ($t = 2.27$, ES = .52, $p < .05$; Table 1).² To control for the effect of the dif-

²Because of the difference between groups at baseline, we controlled for T_0 autonomous motivation in all analyses.

ferences between dropouts and completers, two regression analyses were performed. First, baseline (T_0) values of perceived competence and controlled motivation were regressed onto the change in vitality from T_0 to T_2 and second onto change in SWB from T_0 to T_2 . None of the models were significant, for vitality: $F(2,114) = 1.89$, ns; and for SWB: $F(2,113) = 1.34$, ns. Given these findings, we did not include these baseline measures as control variables in further analyses.

Main analyses

Changes within groups

The exercise condition significantly increased autonomous motivation ($t = 4.89$, $p < .001$), perceived competence ($t = 2.95$, $p < .01$), subjective vitality ($t = 3.84$, $p < .001$), and SWB ($t = 3.50$, $p < .001$). The control group significantly decreased their controlled motivation ($t = -2.48$, $p < .05$) and increased their SWB ($t = 3.06$, $p < .01$).

Table 2 Correlations Among Change Scores

Measure (time)	1	2	3	4	5	6	7	8
1. Exercise versus control	—							
2. Autonomous orientation (T ₀)	.01	—						
3. Controlled orientation (T ₀)	.00	-.07	—					
4. Impersonal orientation (T ₀)	-.10	-.16	.69**	—				
5. Change in autonomous motivation (T ₀ -T ₁)	.42**	.04	-.04	.01	—			
6. Change in controlled motivation (T ₀ -T ₁)	.10	-.09	.16	.28**	.29**	—		
7. Change in perceived competence (T ₀ -T ₁)	.22**	.26**	-.03	-.04	.25**	.04	—	
8. Change in vitality (T ₀ -T ₂)	.12	.00	.01	.00	.27**	-.08	.23**	—
9. Change in subjective well-being (T ₀ -T ₂)	.00	.04	-.03	-.12	.05	-.22*	-.01	.52**

Note. $n = 118$, T₀ = baseline, T₁ = ±Week 7, T₂ = post-assessment.

Change = residual scores controlling for baseline value.

* $p < .05$. ** $p < .01$ (predicted correlations are tested one-tailed, otherwise a two-tailed test is used).

Differences between groups

The residual change scores were used when testing the difference between exercise and controls in the outcome variables. A significant difference was observed for change in autonomous motivation ($t = 4.84$, $p < .001$) and perceived competence ($t = 2.57$, $p < .05$), indicating that the exercise condition increased their autonomous motivation and perceived competence more than the controls. Thus, Hypothesis 1 was supported for the effect of exercise on the two motivational variables. There was no significant difference between the two groups for change in vitality ($t = 1.33$, ns) or SWB ($t = .03$, ns).

Relations among variables

Table 2 shows that exercise was significantly related to change in autonomous motivation ($r = .42$, $p < .001$) and perceived competence ($r = .22$, $p < .05$), again confirming Hypothesis 1. Change in autonomous motivation and perceived competence was significantly related to changes in subjective vitality over the trial ($r = .27$, $p < .01$, and $r = .23$, $p < .05$, respectively), but not SWB, partly supporting Hypothesis 2. The change in controlled motivation was negatively related to changes in SWB ($r = -.22$, $p < .05$), but not vitality. For the causality orientations, there was a significant relation between autonomous orientation and change in perceived competence ($r = .26$, $p < .01$), and between impersonal orientation and change in controlled motivation ($r = .28$, $p < .01$).

Testing the SDT process model

We used multiple regression analysis in order to test the hypothesis that the relation between exercise (relative to control) and change in well-being over 16 weeks is indirect through changes in motivational variables over the first 7 weeks of the trail (Figure 2). Of the predictors hypothesized, autonomous and impersonal causality orientations were

included in the model because of their significant correlations to change in perceived competence and controlled motivation (Table 2).

First, the dichotomous variable (exercise vs. control), autonomous orientation, impersonal orientation, and T₀ autonomous motivation was regressed onto T₁ autonomous motivation, thus controlling for baseline autonomous motivation. The model was significant, $F(4,104) = 26.41$, $p < .001$, and yielded a significant effect of exercise on change in autonomous motivation ($\beta = .32$, $p < .001$). The same variables were entered into the equation, but with controlled motivation T₁ as dependent and controlled motivation T₀ as independent. The model was significant $F(5,103) = 20.92$, $p < .001$, and impersonal orientation was related to a change in controlled motivation from baseline to Week 7 ($\beta = .25$, $p < .01$). Next, perceived competence at T₁ was included as the dependent variable, and baseline perceived competence, autonomous motivation, autonomous orientation, impersonal orientation, and exercise versus control as independent variables. This model was significant as well, $F(5,103) = 11.84$, $p < .001$. Participants' autonomous orientation significantly affected the change in perceived competence from baseline to Week 7 ($\beta = .22$, $p < .01$), while exercise affected the change in perceived competence ($\beta = .15$, $p < .05$, one-tailed).³ In addition, baseline autonomous motivation was related to change in competence ($\beta = .29$, $p < .01$; Figure 2).

In Step 2, two models were tested, one for change in vitality and one for change in SWB. First, the exercise (versus control), autonomous orientation, and impersonal orientation at T₀, the residual changes in autonomous motivation, controlled motivation, perceived competence, and T₀ vitality were regressed onto T₂ vitality. The model was significant, $F(8,101) = 32.65$, $p < .001$. Changes in autonomous motivation ($\beta = .15$, $p < .01$), controlled motivation ($\beta = -.13$,

³One-tailed test used for predicted links.

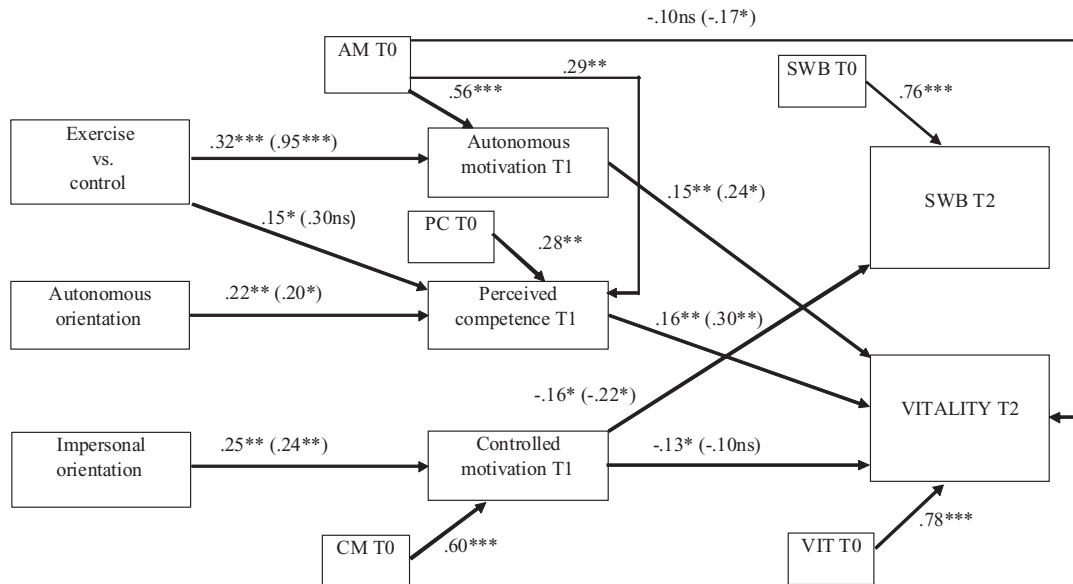


Figure 2 The SDT process model. T₀ = baseline, T₁ = Week 7, T₂ = Week 16. * $p < .05$, ** $p < .01$, *** $p < .001$. AM = autonomous motivation; CM = controlled motivation; PC = perceived competence. Only significant paths ($p < .05$) are shown in the model. One-tailed test is used for predicted paths. Point estimates (A and B paths) from the bootstrapping procedures are shown in parentheses.

$p < .05$), and perceived competence ($\beta = .16, p < .01$) from T₀ to T₁ were significantly related to vitality at T₂, while controlling for baseline autonomous motivation and vitality. No significant effects on vitality were observed for baseline autonomous motivation ($\beta = -.10$), autonomous orientation ($\beta = -.06$), impersonal orientation ($\beta = .02$) nor exercise ($\beta = .05$). The three motivational variables change scores explained 12% of the change in vitality, $F(3,111) = 5.07, p < .01$. Second, the same model was tested for SWB with all change scores including T₀ autonomous motivation and T₀ SWB regressed onto T₂ SWB. This model was also significant, $F(8,100) = 21.49, p < .001$, and there was a negative and significant effect of controlled motivation on change in SWB ($\beta = -.16, p < .05$; Figure 2). Changes in the three motivational variables explained 6% of the change in SWB, $F(3,110) = 2.42, p < .10$, and only change in controlled motivation was negatively related to change in SWB ($\beta = -.26, p < .01$).

Mediational analyses

The five indirect links to change in vitality and SWB emerging in Figure 2 was tested with a bootstrapping procedure involving bias-corrected confidence intervals (BCCI) and resampling techniques (Preacher & Hayes, 2008; Shrout & Bolger, 2002).

The indirect paths between exercise and increased vitality through change in autonomous motivation were supported by the BCCI indicating beneficial effect of the proposed mediator (point estimate = .23, SE = .13, BCCI = .04_{lower} to .57_{upper}, $R^2 = .09$). The path through change in perceived competence was marginal (point estimate = .09, SE = .07, BCCI = -.01_{lower} to .29_{upper}, $R^2 = .11$), with a significant partial effect of T₀ autonomous motivation on vitality (point estimate = -.17, SE = .07, $p = .02$).

The indirect link from autonomous orientation to change in vitality through perceived competence was also supported in the bootstrapping analyses (point estimate = .06, SE = .04, BCCI = .01_{lower} to .17_{upper}, $R^2 = .10$). The path from impersonal orientation via controlled motivation was not supported for change in vitality (point estimate = -.02, SE = .03, BCCI = -.09_{lower} to .03_{upper}, $R^2 = .02$), or change in SWB (point estimate = -.05, SE = .03, BCCI = -.12_{lower} to .00_{upper}, $R^2 = .07$) although the BCCI indicated that the relation to change in SWB is most likely negative.

To investigate whether the participant's causality orientations moderated the effects of exercise on changes in the motivational variables, we tested interactions between the dichotomous variable (exercise vs. control) and the three causality orientations. None of the interaction terms was significantly related to change in perceived competence, autonomous motivation, or controlled motivation. Thus,

a moderated mediation was not observed in the present study.

Discussion

The aim of this study was to identify and test the effects of possible mediators and moderators of the exercise–well-being relation among older adults using the SDT process model (Deci & Ryan, 2000; Williams et al., 2004, 2006). Results supported that the exercise intervention increased autonomous motivation and perceived competence from baseline to Week 7, which both affected a positive change in vitality over 16 weeks. Increased controlled motivation was related to a decrease in both vitality and SWB. Further, participants' differences in personality, as reflected in autonomous and impersonal orientation, were related to changes in competence and controlled motivation, respectively. Regarding the hypothesized mediated paths, Baron and Kenny (1986) hold that the independent variable should be significantly correlated to the outcome (well-being), which it was not. However, it has been discussed whether this criteria is necessary in order to test the indirect effects for distal processes when it is theoretically reasoned (Preacher & Hayes, 2008; Shrout & Bolger, 2002). Therefore, we proceeded testing the indirect links in bootstrapping analyses and found that exercise was indirectly linked to change in vitality over the 16 weeks through change in autonomous motivation and marginally through perceived competence. The link between autonomous orientation and change in vitality through change in perceived competence was also supported.

To our knowledge, this study is the first to include SDT as a theoretical framework when identifying possible mediators of the exercise–well-being relationship among older adults. By using SDT practical cues for people working with older adults on how to intervene on these mediators are provided (e.g., Edmunds et al., 2007b; Tessier et al., 2008). The exercise group increased their autonomous motivation compared to the wait-list control group. A decrease in controlled motivation occurred in the control group, but there were no substantial changes in controlled motivation in the exercise group. This finding is in line with recent evidence indicating that the change in internalized regulations such as autonomous motivation is more likely to occur following exercise than controlled forms of regulation (Wilson & Rodgers, 2008; Wilson et al., 2003). The participants had not been involved in structured training the last months before commencement, and most of them reported walking as their main activity. The new structured training program and the autonomy-supportive instructors appeared to enhance their autonomous motivation as they found it more enjoyable, interesting, and important. Few exercise trials have actually investigated the effects of the participant's motivation for being physically active. For example, most participants in intervention studies

among older adults are volunteers suggesting that they are motivated to exercise, but the effect of the quality of their motivation on different outcomes has not been investigated.

The increase in autonomous motivation was important in light of propositions within SDT because autonomous motivation toward important life domains should lead to higher well-being (Deci & Ryan, 2000). Supporting this, we found that increased autonomous motivation was related to a positive change in vitality, while controlled motivation decreased both vitality and SWB. SDT distinguish between eudaimonic well-being (vitality) and hedonic well-being (SWB), because hedonic well-being may arise from achieving desires, while eudaimonia rise from satisfaction that is a result of self-actualization and optimal functioning (Nix et al., 1999; Ryan & Deci, 2001). Our results indicate that there could be different correlates to the two well-being measures, and support SDT in that autonomous behavior may be closer related to vitality (Nix et al., 1999). In addition, SDT holds that when people exercise due to feelings of pressure from within (e.g., guilt) or from others (e.g., family or physician), they will not experience increased well-being from doing the behavior (Deci & Ryan, 2000). Therefore, the quality of the older adult's motivation as reflected in autonomous or controlled motivation seem important for their well-being outcomes of exercise. The implications for practice of these findings would be that future interventions among elderly should focus more on trying to nurture autonomous rather than controlled types of motivation, for example, through autonomy support.

When examining the SDT process model, we observed a significant positive relation between increased perceived competence and change in vitality, and perceived competence was a marginal mediator of the effect of exercise on vitality. The increase in perceived competence observed in the exercise group, at least among the autonomously motivated participants, suggests that they found the protocols adequately challenging and felt progress in relation to their training. This may have resulted in a higher sense of physical function and self-actualization again increasing their competence and vitality (Nix et al., 1999; Ryan et al., 2008). Our results therefore support the proposition that indicators of competence may increase as a result of successful engagement in exercise, again influencing global well-being among older adults (McAuley et al., 2006).

No studies have tested the possible moderating effect of individual differences in causality orientations on the relation between exercise and change in motivational variables. In the current study, no such moderated effects were found, and the exercise affected the change in participant's autonomous motivation and perceived competence independent of their causality orientations. In the analyses, a high initial autonomous orientation was related to a greater increase in perceived competence, which in turn increased vitality. The

reason for the relation to change in perceived competence could well be that autonomously oriented persons more easily set challenging self-endorsed goals, again giving rise to more personal control over outcomes. In contrast to Williams et al. (1996), no relation between autonomous orientation and change in autonomous motivation was observed. While the nonsignificant relation between autonomous orientation and change in autonomous motivation is not readily explainable, it may be that autonomous orientation affects autonomous motivation through perceived competence. While some research findings have indicated that autonomous motivation is a consequence of perceived competence (Chatzisarantis et al., 2003; Halvari & Halvari, 2006; Teixeira et al., 2006), Williams et al. (2004, 2006, 2009) have found that autonomous motivation is a precursor of competence. In the present study, the zero-order correlation between change in perceived competence and change in autonomous motivation was significant ($r = .25, p < .01$), but the sequencing of change could not be tested directly because the motivational variables were measured simultaneously and they were therefore placed at the same level in the model. Nevertheless, the relation between baseline autonomous motivation and change in perceived competence was significant ($r = .34, p < .01$), while the relation between baseline competence and change in autonomous motivation was nonsignificant ($r = -.10$). This finding indicates that autonomous motivation is a precursor of competence, and that those high in autonomous motivation at commencement had a larger increase in competence during the first 7 weeks of the trial.

Rose et al. (2001) suggested that it is important to take the predominant orientation into account in the adoption stages to foster maintenance of the exercise behavior. This proposal was supported in that impersonal orientation was related to an increase in controlled motivation, which again negatively influenced SWB. Previous studies have suggested that participants high in self-determined motivation felt more self-determined with an autonomy-supportive supervisor, than participants low in self-determination (Richer & Vallerand, 1995). Thus, the training of the instructors to behave in an autonomy-supportive manner was probably not right for the impersonally oriented individuals, as they might prefer instructors to behave in a more controlling style. The reliability of the impersonal orientation subscale was borderline low, so this finding should be interpreted with caution. There was also a tendency for those with low perceived competence and high controlled motivation at baseline to withdraw from the study. Dropouts occurred primarily in the first 7 weeks of the trial, and some of the elderly pointed out that their family had informed them about the study and perhaps they felt some external pressure to assign, indicating controlled forms of motivation. This is an interesting finding in itself in that controlled motivation may be positive for attaining exercise (Markland & Ingledew, 2007), but not for behavioral

persistence (Pelletier, Fortier, Vallerand, & Brière, 2001). The present study highlights the importance of identifying people's causality orientations and controlled motivation at baseline. By doing that, their motivation might be nurtured by fostering an environment that supports their orientation at least in the initial stages of a program (Rose et al., 2001).

Limitations of the study include the somewhat modest sample size ($n = 118$), and that the duration of the intervention was limited. The sample consisted of relatively well-educated and physically well-functioning elderly. In addition, those with low well-being, perceived competence, and high controlled motivation at baseline tended to drop out. Thus, the present results may only generalize to those initially well functioning and with high perceived competence and low controlled motivation for exercise. Volunteers tend to be fitter, better educated, more social and mentally healthier than average (Oken et al., 2006). Others have suggested that people low in well-being at baseline may benefit more from exercise programs (Oken et al., 2006; Rejeski & Mihalko, 2001). Thus, the relatively small correlations and changes observed could be a result of participants experiencing high levels of well-being at commencement. In addition, the motivated (autonomous) participants likely entered the program with some expectations about the benefits (both physical and mental), and their expectations may have increased the effect of the intervention (Fox, Stathi, McKenna, & Davis, 2007; Oken et al., 2006). Therefore, upcoming studies would do well to sort out how to recruit people not motivated to exercise. Further, there was no substantial difference between the two groups in changes in well-being due to an increase in the control group. This increase was probably caused by the nature of the design reflecting the positive expectations in the control group toward beginning exercise after being on the wait-list. Timing of measurements may have affected the results, as it has been indicated larger effects on well-being for exercise trials lasting up to 6 weeks compared to studies lasting over 12 weeks (Arent et al., 2000). Therefore, multiple assessments of both mechanisms and well-being indices should be carried out.

The mental health benefits from exercise include both increased well-being, such as self-esteem, vitality, life satisfaction, and reductions in levels of ill-being such as depression, anxiety, and chronic stress (Fox et al., 2007; Wilson et al., 2008). Consequently, expanding the current study, future research should investigate psychological effects of exercise using additional indices of well-being (e.g., self-esteem) and also include measures of ill-being (e.g., depression). In particular, controlled motivation could possibly have a stronger relation to indices of ill-being than the positive well-being variables measured here. Finally, the participants were randomized to an exercise group. Larger effects on autonomous motivation, perceived competence, and well-being would

probably have been observed with prescribed exercise in relation to participants' needs and wishes.

The current study focused on motivational variables, but the three needs for autonomy, competence, and relatedness could also operate as mediating mechanisms between exercise and well-being (Deci & Ryan, 2000). The effect of need satisfaction in exercise among older adults is not known, and later studies should investigate the effect of each need on well-being among elderly. Strengths of the present study include using older adults as participants and that these older adults revealed relatively low levels of activity the last 6 months before the intervention compared to other exercise studies testing the tenets of SDT (e.g., Edmunds et al., 2008; Wilson & Rodgers, 2004). Participant's individual differences in personality were also included when examining the SDT process model. This has been a neglected area in the SDT exercise literature.

In summary, the major finding was that exercise-specific measures of autonomous motivation and perceived competence affected the older adult's changes in vitality, and that

controlled motivation was negatively related to change in SWB and vitality. This is important given that intervening on factors that are modifiable to change in the exercise setting can increase general feelings of well-being (McAuley et al., 2006). Therefore, the results have practical implications for those interested in enhancing well-being following exercise among older adults, and our findings suggest that SDT works as a proper theoretical framework when investigating mechanisms of the relation between exercise and well-being in older adults.

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PAPER IV

A one-year follow-up of effects of exercise programs on well-being in older adults

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Abstract

Purpose: To investigate the long-term effects of three types of training on well-being and frequency of physical activity, and whether pre-intervention motivation moderates the effects. **Methods:** 62 older adults ($M = 75$ yr, $SD = 5$; 61% females) completed 4-month programs of endurance, functional or strength training, with re-assessment of well-being (life satisfaction, positive affect, negative affect, vitality) and physical activity 12 months later. **Results:** All groups showed small improvements in most measures of well-being at 4 months. At follow-up, endurance training still had small beneficial effects, while changes with functional and strength training were generally trivial or harmful. Analysis for moderators indicated that autonomously motivated individuals better maintained gains in well-being and had higher frequencies of physical activity at follow-up compared with controlled individuals. **Conclusion:** Endurance training is recommended for older adults, but the long-term outcomes depend on the individual's motivational regulation at commencement.

Introduction

Several exercise trials have been conducted to investigate effects of exercise on well-being and physical activity among the elderly, and there is good evidence that structured exercise interventions involving older adults are effective (Arent, Landers, & Etnier, 2000; Muller-Riemenschneider, Reinhold, Nocon, & Willich, 2008; Netz, Wu, Becker, & Tenenbaum, 2005). Less is known about long-term effects or maintenance of gains after cessation of programs (Rhodes et al., 1999; Schutzer & Graves, 2004; Van der Bij, Laurant, & Wensing, 2002), but participants often fall back to their pre-intervention levels of well-being (De Vreede et al., 2007; McAuley, Blissmer, Katula, & Duncan, 2000) or physical activity (King, Rejeski & Buchner, 1998; Muller-Riemenschneider et al., 2008; Van der Bij et al., 2002). A better understanding of factors that affect effectiveness of interventions after cessation might lead to more successful programs (Schutzer & Graves, 2004). These factors include the type of exercise in the structured program and the psychological characteristics of the participants (King, 2001; Van der Bij et al., 2002). In this study we have examined both kinds of factor.

Most studies of exercise in the elderly have included aerobic and strength training (Arent et al., 2000; Netz et al., 2005), but recently beneficial effects have been shown with other types of training, such as yoga (Oken et al., 2006), power training (Henwood & Taaffe, 2008; Katula, Rejeski, & Marsh, 2008) and functional training (Whitehurst, Johnson, Parker, Brown, & Ford, 2005). However, there is ambiguity in what type of exercise is best for maintaining well-being and activity (King et al., 1998; McAuley et al., 2007). In the present study we investigated follow-up effects of endurance and strength training. We included a third group performing functional training, which may be a cost-

effective alternative to strength training. With functional training several people can exercise simultaneously, less equipment is needed, and one instructor can lead a group. In addition, the elderly might maintain a program of functional training more easily after cessation compared to other forms of strength training. McAuley and colleagues (2000) compared outcomes of a 6-month moderate intensity walking program (aerobic) with those of a toning program (non-aerobic) 6 months after cessation. Both groups increased life satisfaction and happiness during the intervention, but decreased to below baseline at follow-up. Five years later participants in the walking program reported higher levels of physical activity compared to those in the toning program (McAuley et al., 2007). In another study, there was a decrease in physical activity in the strength group compared to the functional group, while the functional group decreased below baseline in perceived physical function six months after a three-month trial (DeVreede et al., 2007). Inaba, Obuchi, Arai, Satake and Takahira (2008) measured quality of life 1 year after a 3-month progressive resistance program; about half the participants voluntarily continued training for 12 months while the other half went back to their daily routines. Both groups showed decreases in quality of life from post-intervention to follow-up, but the group returning to their daily routines decreased more than those continuing exercise. Taken together, these results indicate a need for more studies of long-term outcomes with different kinds of training. Thus, the first aim of this study was to evaluate the long-term effects of three exercise programs on well-being in older adults.

Several authors have called for investigation of the effects of participants' pre-intervention psychological characteristics on the outcomes of exercise trials (McAuley & Morris, 2007; Rejeski & Mihalko, 2001; Wiedemann, Lippke, Reuter, Ziegelmann, &

Schwarzer, 2011). Recently, Wiedemann and colleagues (2011) tested the effect of two different baseline stages of behavior change by comparing those motivated but not acting (intenders) with those already active (actors). The overall effect of a 4-week intervention on physical activity levels was trivial (standardized mean change $d = .16$), but they found larger effects for intenders than actors ($d = .84$). Likewise, the value or importance placed on exercise behavior is another possible moderator of the effects of exercise on well-being among older adults (Elavsky et al., 2005; McAuley & Morris, 2007; Rejeski & Mihalko, 2001). Proponents of self-determination theory (SDT; Deci & Ryan, 1991, 2000) hold the view that the underlying reason for pursuing a behavior is an important predictor of the behavior and well-being. Within SDT, motivation for a behavior is viewed as a continuum, ranging from intrinsic regulation (the most self-determined form) through identified, introjected and external (the least self-determined form) (Ryan & Connell, 1989). Intrinsic and identified regulation have also been classified as autonomous, while extrinsic and introjected regulation have been classified as controlled (Deci & Ryan, 2000; Williams, McGregor, Zeldman, Freedman, & Deci, 2004). Others have linked enjoyment (an indicator of intrinsic motivation) to participation in exercise (Rhodes et al., 1999; Salmon, Owen, Crawford, Bauman, & Sallis, 2003). According to SDT, autonomously motivated individuals will experience more pleasure from performing exercise and therefore increase their well-being compared to those with controlled motivation (Deci & Ryan, 2000; Ryan & Deci, 2002). There is considerable evidence supporting this contention. Cross-sectional research has positively related autonomous forms of motivation for exercise to indices of well-being (Puente & Anshel, 2010; Thøgersen-Ntoumani & Ntoumanis, 2006) and physical activity behavior

(Edmunds, Ntoumanis, & Duda, 2006; Wilson, Rodgers, Blanchard, & Gessell, 2003; Wilson & Rodgers, 2004). In prospective studies of young sport participants, persistence was positively related to intrinsic and identified regulation (Pelletier, Fortiér, Vallerand, & Brière, 2001), and negatively related to drop out up to two years later (Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002). Furthermore, autonomous motivation has been positively related to participation in optional physical education a year later, while external and introjected regulations were unrelated or negatively related to persistence over time (Ntoumanis, 2005). In relation to well-being indices in exercise, Wilson and Rodgers (2002) found a positive relation between identified and intrinsic regulation and physical self-esteem measured 8 weeks later, and a negative relation was observed for external regulation. Hence, pre-intervention motivation may be an important predictor for the long-term effects of an exercise program. Unfortunately, little is known about such effects in older adults, and few researchers have investigated the effect of motivational regulation on different indices of well-being over time in any subjects. The volunteers in a training study have motivation to participate (Oken et al., 2006), but it is not known whether type of motivation affects the outcomes. Therefore, the second aim of the present study was to examine the effect of pre-intervention motivational regulation on long-term changes in well-being and physical activity among older adults.

Method

Study Design and Participants

The present study is based on the 12 months follow-up data from a 4-month exercise-intervention among older adults. For a detailed description of the recruitment

strategies, inclusion and exclusion criteria, randomization procedures and training protocols see (Solberg et al., 2013). Briefly, of the 284 potential participants who responded to the poster and newspaper advertisements, 138 ($M = 74$ yr, $SD = 5$, 68% females) were eligible and were randomly allocated to one of four groups: endurance training, functional strength training, traditional strength training, and wait-list control (Figure 1). Participants in the wait-list control group were not included in the present analyses, because they were offered similar training as the exercise groups after the 4-month intervention period. Participants completing the 4-month intervention were offered a weekly session of aerobic or strength training at the intervention site at their own cost.

Data were recorded at baseline (T0), and after the 4-month exercise-intervention (T1). Twelve months after cessation of the trial, the 85 participants completing the exercise intervention were contacted for follow-up measurement (T2, 16 months). Frequency of physical activity was measured at baseline and 16 months. The possible moderator (motivational regulation) was measured at baseline (T0), before randomization of participants to the programs.

All participants provided written informed consent prior to the trial. The study was approved by the Regional Ethics Committee of Southern Norway and the Norwegian Data Inspectorate.

*** Figure 1 near here***

Intervention Groups

The trial lasted 4 months, including 2 weeks familiarization and pre-testing, 13 weeks exercise and 1 week post-testing. Training sessions were performed three times per

week and each training session lasted 60 min, including 10 min of general warm up and 10 min stretching. All exercise sessions were led by an instructor.

The *endurance training* group performed Nordic walking, aerobics and hiking each on separate days. Rating of perceived exertion was moderate ($M = 13.4$, $SD = 2.3$) across the three variants of endurance training on the 6-20 Borg scale (1982).

The *functional training* group performed a circuit training involving eight loaded exercises mimicking activities of daily living (e.g., chair raise, case lifts, stair climbing). Participants did two sets, starting with 15 RM (repetition maximum) in the first 7 weeks and 12 RM in the last 6 weeks. Load was increased gradually with weight-vests and dumbbells. Mean perceived exertion was 14.5, $SD = 0.9$.

The *strength training* group followed a mix between daily undulating periodization and linear periodization starting with 12-8 RM, and ending with 8-4 RM while increasing load. Participants did one to three sets each of eight traditional exercises: squat, knee extension, calf raise, chest press, seated row, shoulder press, abdominals and lower-back exercises. Perceived exertion was not assessed in strength training, which was by definition a high-intensity protocol using repetition maximum.

The 19 instructors used in the study were trained over two sessions to provide autonomy support following guidelines emanating from self-determination theory (Deci, Eghrari, Patrick, & Leone, 1994; Mageau & Vallerand, 2003). The training was done to ensure that the instructors acted and communicated in a standardized and positive manner across the three training groups. In particular, instructors were trained to emphasize positive feedback, learning names, involving the participants, and to give a rationale for

all exercises. Participants were also given choice to select warm-up routines in their exercise programmes.

Dependent Variables

Life satisfaction was assessed with the 5-item scale of Pavot and Diener (SWLS; 1993). Participants responded to the items (e.g., “I am satisfied with my life”) on a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true). Cronbach’s alpha had acceptable values of .79 at T0, .80 at T1, and .82 at T2.

Affect was assessed with a short 12-item version of the positive and negative affect schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants rated to what degree they had experienced 6 positive (e.g., alert, excited) and 6 negative (e.g., upset, irritable) feelings in the last 4 weeks on a 5-point Likert scale anchored by 1 (not at all) and 5 (very much). Alpha reliability was .85, .81 and .91 for positive affect and .81, .84 and .87 for negative affect at T0, T1, and T2, respectively.

Vitality was measured with the trait version of Ryan and Frederick’s (1997) subjective vitality scale. Participants answered 6 items (e.g., “I have energy and spirit”) on a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true). Alpha values were .90 at T0 and T1, and .92 at T2.

All well-being scales have been used previously among older adults and shown to change following different types of exercise (Mihalko & McAuley, 1996; McAuley et al., 2000).

Frequency of physical activity was measured with one question asking the participants to indicate how often they are usually physically active (Statistics Norway,

2009). The answer alternatives were: 1 (never), 2 (less than once every second week), 3 (once every second week), 4 (once a week), 5 (2 times per week), 6 (3-4 times per week), 7 (5-6 times per week), 8 (once or more every day).

Moderator Variable

Motivation for exercise was measured with a slightly modified version of the 15-item behavioral regulation in exercise questionnaire (BREQ; Mullan, Markland, & Ingledew, 1997). In a pilot test one of the identified items (“I get restless if I don’t exercise regularly”) loaded on the introjection sub-dimension and was replaced with one item (“It’s important to me”) from the treatment self-regulation questionnaire (TRSQ; Williams, Grow, Freedman, Ryan, & Deci, 1996). In addition, because a previous study had shown borderline low alpha reliability among younger participants on the introjection sub-scale (Wilson et al., 2003), one introjection item from the TRSQ was added (“I feel bad about myself for not exercising”). The final version had 16 items: 4 on each subscale reflecting intrinsic, identified, introjected and external regulation. Participants responded on a 5-point Likert scale ranging from 1 (not true for me) to 5 (very true for me).

A maximum likelihood factor analyses indicated that the 16 items reflected three motivation factors: autonomous (intrinsic and identified items), introjection and external. Total variance explained was 57%. There was a high correlation between the intrinsic and identified regulations ($r = .74$). Therefore, we estimated three motivation variables: autonomous, introjection, and external regulations (e.g., Silva et al., 2011). In the present study, Cronbach’s alpha was acceptable for autonomous regulation (.89), introjection regulation (.86) and external regulation (.81).

Statistical Analyses

For the analyses pertaining to the first aim (changes in well-being and physical activity behavior) the sample size was about 20 participants in each group, similar to that in previous studies investigating relations between exercise and well-being (Cassilhas et al., 2007; De Vreede et al., 2007). In the analyses pertaining to the second aim (effects of moderators), we collapsed the three exercise groups to increase statistical power and to have more individual responses to explain. The small proportion of missing items in the psychometric scales (<2%) appeared random; these items were therefore replaced using a general linear model combining main effects of items and subjects (Roth, Switzer, & Switzer, 1999). All data were analysed with SPSS (version 18.0; Chicago, Illinois).

For the preliminary analyses of differences between dropouts and completers, the unequal-variances t statistic and the chi-squared statistic were used for the comparison of means and proportions respectively. The p values provided by the relevant procedures in SPSS were transformed into confidence limits and mechanistic inferences (see below) using a spreadsheet (Hopkins, 2007).

In the primary analyses, the linear mixed model procedure was used to examine the effects of the three training types on changes in well-being and physical activity behavior, with baseline value of the variable as covariate. Mixed modelling was adopted to properly account for non-uniformity arising from the individual responses in the different groups. The mixed model consisted of fixed effects (to estimate mean effects of training and covariates) and random effects (to estimate individual responses and residual error as standard deviations). Dummy variables (coded 0 and 1) were included in the model as fixed effects to represent the absence or presence of a condition and as random effects to

estimate additional variance representing individual responses. The effects of the baseline values on the dependent within groups was assessed by including the baseline as a covariate interacted with each treatment group (accounting for individual responses to the treatments attributable to the pre-intervention value of the variable of interest). Individual responses were estimated in the two groups with the largest standard deviation of change scores relative to the group with the smallest standard deviation (which was assigned the residual variance). Effects of the proposed moderators on changes in well-being and activity were estimated with a separate linear regression for each moderator; the model included the baseline value of well-being or activity as a predictor¹.

All changes in means are presented as standardized effect sizes (ES) by dividing the mean by the standard deviation of the baseline value of the dependent variable for all completers ($n = 62$). The magnitude of the effect of the pre-intervention value (moderator) on the dependent variable of interest was evaluated as a difference of two standard deviations (SD) of the moderator to represent the difference between those high (+1SD) and low (-1SD) on the variable (Hopkins, Marshall, Batterham, & Hanin, 2009; Wiedemann, Schuz, Sniehotta, Scholz, & Schwarzer, 2009). Magnitude of all standardized effects was evaluated with a modification of Cohen's (1992) scale that aligns standardized effects with the corresponding bi-serial correlations (Hopkins et al., 2009; Rosnow & Rosenthal, 1996): <0.2, trivial; 0.2-0.6, small; 0.6-1.2, moderate; >1.2, large. Magnitudes of differences in proportions between groups were evaluated using a related

¹ Gender was not included as a covariate in any of the models, owing to the low number of males within the groups, and because the distribution of gender was reasonably similar to that of the population for this age group in Norway (Statistics Norway, 2011). In addition, no clear difference between men and women in the relationship between exercise and well-being has been found (Netz et al., 2005).

scale: <10%, trivial; 10-30%, small; 30-50%, moderate; >50%, large (Hopkins et al., 2009).

Uncertainty in the estimate of an effect of exercise on well-being and physical activity was expressed as 99% confidence limits (CL) and as probabilities that the true value of the effect was beneficial, trivial or harmful in relation to threshold values for benefit and harm of ± 0.20 standardized units. These probabilities are not presented quantitatively but were used to make a qualitative probabilistic clinical inference about the effect in preference to a statistical inference based on a null-hypothesis test. The approach of reporting magnitudes of effects in probabilistic terms properly addresses their uncertainty in sample-based studies, regardless of the sample size (Hopkins et al., 2009). Briefly, the effect was deemed unclear when the chance of benefit was sufficiently high to warrant use of the treatment, but the risk of harm was unacceptable. Such unclear effects were identified as those with an odds ratio of benefit to harm of < 66 , a ratio that corresponds to an effect that is borderline possibly beneficial (25% chance of benefit) and borderline most unlikely harmful (0.5% risk of harm). All other effects were deemed clinically clear and expressed as the chance of the true effect being trivial, beneficial or harmful with the following scale: 25-75%, possibly; 75-95%, likely; 95-99.5%, very likely; >99.5%, most likely (Hopkins, 2007). Only effects shown as at least possibly beneficial should be considered for implementation. Magnitudes of covariates and of differences between completers and dropouts were evaluated mechanistically (Hopkins et al., 2009): if the confidence interval overlapped thresholds for substantial positive and negative values (± 0.20 standardized units for means, $\pm 10\%$ for proportions), the effect was deemed unclear; all other effects were deemed clear and were evaluated

probabilistically as described above. Whereas we have made no adjustment for inflation of error with clinical inferences, we have been more conservative with the larger number of mechanistic inferences by determining the clarity of outcome with a 99% confidence interval rather than a 90% confidence interval. For this reason all confidence intervals are shown at the 99% level.

Results

Compliance

Of the 99 participants allocated to one of the three training groups (Figure 1), 85 ($M = 74.1$ yr., $SD = 4.7$, 66% females) completed the 4-months exercise intervention, and 62 ($M = 74.5$ yr., $SD = 5.1$, 61% females) completed the follow-up assessments at 16 months (Table 1).

Table 1 near here

There were some small baseline differences between the three exercise groups in body mass index, age, gender, living alone, education and negative affect. Differences for the other characteristics were trivial (Table 1). We controlled for each variable in the comparison of the dependent variable between groups, but their effects were trivial and they were not included in further analyses. In addition, there were some small clear differences between the participants lost to follow-up ($n = 37$) compared to completers assessed at 16 months ($n = 62$), with the dropouts tending to be females, living alone, having lower education and reporting less physical activity at baseline (Table 1).

Of the participants completing follow-up measurements, 55% reported having continued to participate in training groups at the intervention site after cessation. There

were a few small differences between those continuing ($n = 34$) and those not ($n = 28$): continuers showed a relative increase in vitality (standardized effect size, $ES = .25$, 99% $CL \pm .46$) and positive affect ($ES .28$, $CL \pm .53$) between 4 and 16 months, and they reported a relative increase in physical activity between 0 and 16 months ($ES .51$, $CL \pm .81$). The differences in baseline motivation were small/trivial and unclear between continuers and non-continuers for all regulations: autonomous ($ES .22$; $CL \pm .70$), introjection ($ES -.02$, $CL \pm .67$) and external ($ES -.17$, $CL \pm .70$). Thus, there was no clear tendency for those autonomously motivated at baseline to continue exercise at the intervention site. We controlled for the differences in motivation between continuers and non-continuers, but the effect on the outcomes was trivial.

Main Effects of the Programs

Changes in indices of well-being and frequency of physical activity during and following the three exercise programs are shown in Table 2. There were generally trivial or small clear negative effects of baseline value of the dependent variables in all programs over the three measurement points, indicating that those with higher well-being had less benefit (data not shown).

Table 2 near here

Changes during the intervention (0 to 4 months). There were clear and beneficial increases in positive affect and vitality with all three programs during the intervention period. These changes are similar to results reported elsewhere with a larger sample (Solberg, Hopkins, Ommundsen, & Halvari, 2012; Solberg et al., 2013). In addition,

functional training increased life satisfaction, and endurance training decreased negative affect.

Where the different programs produced similar changes, comparisons between programs were unclear. However, functional training showed clear differences for some measures: a possibly beneficial effect relative to strength and endurance training for life satisfaction (ES .24, CL \pm .51, and ES .23, CL \pm .52, respectively), a possibly beneficial effect relative to strength training for positive affect (ES .29, CL \pm .55), and a possibly harmful effect relative to endurance training for negative affect (ES -.27, CL \pm .60).

Changes during follow-up (4 to 16 months). All programs showed trivial or small reductions in the positive indicators of well-being (life satisfaction, positive affect and vitality), while the changes in negative affect were trivial and unclear.

For group comparisons during follow-up, endurance training was possibly beneficial compared to strength training for positive affect and vitality (ES .27, CL \pm .62, and ES .45, CL \pm .59, respectively), while functional training was possibly beneficial compared to strength training for vitality (ES .31, CL \pm .53).

Changes from baseline to follow-up (0 to 16 months). Endurance training was the only program with the possibility of beneficial effects (on positive affect, negative affect and vitality). Effects of functional training were trivial or unclear, while strength training had a small and likely harmful reduction in vitality. There was a moderate to large negative effect of baseline on change in physical activity, indicating that those low in physical activity at baseline became more active.

Endurance training was generally more beneficial relative to the other programs over the 16 months of the study: there was possible benefit for positive affect relative to

strength training (ES .38, CL \pm .85), very likely benefit for vitality relative to strength training (ES .57, CL \pm .54), and possible benefit for vitality relative to functional training (ES .28, CL \pm .47). Functional training was also possibly beneficial relative to strength training for vitality (ES .30, CL \pm .46) and life satisfaction (ES .26, CL \pm .54). There were no clear differences between groups in frequency of physical activity.

Moderation Analysis

Although participants on average generally returned to the mean pre-intervention levels of well-being and activity (Table 2), moderator variables could account for any individual positive and negative responses represented by the standard deviation of change scores, provided at least part of the standard deviation was not due to random error of measurement. For evidence of individual responses that could be explained by moderators, we compared the standard deviations of the change scores with the standard deviations in a 3-month reliability study of positive and negative affect among 60 students (Terracciano, Mccrae, & Costa, 2003). From the correlations and between-subject SD we calculated an error of measurement of .34 for NA and .27 for PA (state version); multiplying these by $\sqrt{2}$, our estimates of the SD of their change scores were \pm .48 and \pm .38, respectively. The standard deviations observed in our data were \pm .59 (T0-T1) and .70 (T0-T2) for PA and \pm .66 (T1-T2) and .60 (T0-T2) for NA, indicating that there were some individual responses to explain. Unfortunately, there were no published data to calculate the error of measurement of the life-satisfaction scale and the subjective-vitality scale. In addition, there were some small-moderate correlations between

motivational and dependent variables at baseline (ranging from -.23 to .39). Thus, there were some indications that baseline motivation could moderate the effects.

Moderation by baseline autonomous motivation. Between 0 and 4 months, there were some small effects of autonomous motivation for negative affect, life satisfaction and vitality (Table 3). Combined with the overall changes in the mean, those with high autonomous motivation (+1SD) experienced a small reduction in negative affect (ES -.23), while those with low autonomous motivation (-1SD) experienced only a trivial change (ES .07). For life satisfaction and vitality, those with high autonomous motivation had a trivial change (ES .05 and .17), whereas those low had a small increase (ES .29 and .45, respectively).

Table 3 near here

There was a small and clear effect of autonomous motivation on vitality between 4 and 16 months. Thus, the decrease in vitality between cessation and follow-up was trivial among those with high autonomous motivation (ES -.11) relative to small/moderate for those with low autonomous motivation (ES -.55).

From 0 to 16 months there was a small and likely positive effect of autonomous motivation on change in frequency of physical activity, resulting in a small beneficial effect among those high in autonomous motivation at baseline (ES .30) compared to trivial for those with low autonomous motivation (ES -.16).

Moderation by baseline introjection regulation. There were two small and clear effects of introjection: between 0 and 4 months the possibly beneficial effect on vitality reflected that those with high introjection benefitted more from the exercise relative to those low (ES .45 vs .17), while between 4 and 16 months those with high introjection at

baseline likely increased their negative affect, while those low had a small reduction (ES .17 vs -.27).

Moderation by baseline external regulation. From 0 to 4 months there were small effects of external regulation on change in life satisfaction, vitality and negative affect, such that those with initial high external regulation increased more than those with low external regulation. Between 4 and 16 months, there were small to moderate effects of external regulation on positive and negative affect: those with high external regulation had a moderate reduction in positive affect (ES -.62) and a small increase in negative affect (ES = .21), compared to those with low external regulation (ES -.12 and -.31, respectively). Overall (0 to 16 months), the effect on life satisfaction was small and clear, but the effects for those with high and low external regulation were both trivial (-.16 and .06, respectively). The likely small negative effect of external regulation on change in positive affect resulted in a trivial reduction for those with high (ES -.13) compared to small increase for those with low external regulation (ES .39). Finally, the small negative effect of external regulation on change in frequency of physical activity resulted in a small reduction for those high (ES -.21), compared to a small increase for those low in external regulation (ES .35).

Discussion

In the present study we investigated long-term effects of a 4-month exercise-trial with endurance, functional and strength training among older adults. From baseline to follow-up, endurance training yielded the best overall outcomes with some small and possibly beneficial effects on the well-being indices. In contrast, strength training had a

clear reduction in vitality. There were no clear changes in frequency of physical activity from baseline to 16 months. Overall, most of the gains in well-being during the intervention were lost for all three groups between cessation and follow-up. We also found that pre-intervention motivation for exercise moderated the overall effects of the intervention: at follow-up autonomously motivated individuals maintained their gains in well-being and increased their level of physical activity compared to those reporting controlled regulation of their motivation.

The reductions observed in well-being between cessation and follow-up are similar to those of other studies (De Vreede et al., 2007; McAuley et al., 2000). There are several possible explanations for this apparent general failure of exercise programs to exert a long-term effect on well-being. First, a response shift may have occurred in the participants, implying that the participants changed their internal standards, values or conceptualization for well-being during the trial (Rapkin & Schwartz, 2004). One process suggested to lead to a response shift during a treatment is a person's standard of comparison (Rapkin & Schwartz, 2004). Second, the two strength training groups may have lost their opportunity to continue this type of training on their own with a similar level of intensity. The strength group in particular increased their muscle strength during the intervention (Solberg et al., 2013). Hence, the participants may have missed the challenges and physical benefits of the program, and it is likely that the participants in endurance training were able to continue their training more easily after the intervention (De Vreede et al., 2007; King et al., 1998; Rhodes et al., 1999). Another reason for the lower long-term effectiveness of strength and functional training could be the loss of security from instructor-led training and the social support from the group. Many older

adults are not confident with strength training and may need supervision, which can be expensive (Rhodes et al., 1999; Salmon et al., 2003). More than half the participants continued supervised training at their own expense, but continuing exercise at the intervention site did not alter the overall long-term effects substantially. It may be that once a week is not enough to maintain gains after a trial.

The beneficial effects of endurance training apparent at the end of the follow-up period may be related to the outdoor setting for this type of exercise. Others have shown that outdoor training may positively affect vitality (Ryan et al., 2010; Plante et al., 2006) and well-being in general (Coon et al., 2011). It is also possible that these elderly participants found it easier to maintain endurance training than strength and functional training after the four-month period of supervision, but the change in level of physical activity in the three groups showed too much uncertainty to provide evidence for or against this possibility. The harmful effect of strength training on vitality at the end of follow-up is less easy to explain. Others have suggested that high-intensity exercise reduces vitality (O'Connor & Puetz, 2005), and the strength-training group did show the smallest increase in vitality during the supervised phase of training. Loss of vitality following this phase may have been due to resetting of participants' standard for reporting vitality via loss of the challenge of the strength-training program.

The apparent lack of change in frequency of physical activity in the groups overall may reflect a ceiling effect, in that the participants were already relatively active (on average twice a week) before the intervention. The intervention itself consisted of three sessions per week with a high adherence rate; the participants therefore increased their frequency of activity while the program lasted, as suggested in another training study of

the elderly (King et al., 1998). The participants then apparently returned to their previous frequency of activity, but a better measure of activity is required to assess whether there was any change in the duration, intensity and mode of activity. A better measure of physical activity in some future study might also reveal whether elderly people who are less active than our participants maintain a higher level of activity following a period of supervised exercise.

Although a substantial proportion (28%) of the participants randomized to the groups was lost to follow-up, none of the dropouts gave dissatisfaction with some aspect of the study as a reasons for dropping out (Figure 1). Furthermore, those with most to gain, especially in frequency of physical activity, were more likely to be lost to follow-up. It follows that the beneficial effects of exercise in this study are unlikely to be biased high by any tendency towards retention of participants experiencing positive outcomes.

In the moderation analyses, the main aim was to explain the changes in well-being and activity with differences in quality of pre-intervention motivation. A moderator explains individual responses, but without a standard deviation from a control group, we used change scores from a reliability study (Terraciano et al., 2003) of young adults for evidence that the individual differences for positive and negative affect were not simply due to error of measurement. The moderation analyses were thus justified, and we used self-determination theory as a theoretical framework to explore moderating effects of participant's pre-intervention motivational regulations on changes in well-being. We expected that the volunteer participants were motivated and valued exercise at some degree, but that there could be different outcomes of the trial based on their underlying quality of reasons for participating, as suggested by Deci and Ryan (2000). We also

included the baseline value of the dependent variables, and it was a clear moderator with generally small and negative effects. The effects of baseline of the dependent variables are explained at least partly by the well-known phenomenon of regression to the mean. Estimation of the real contribution of the baseline to the changes would require a control group. Although there were small to moderate correlations between motivation and dependent variables at baseline, the effect of baseline motivation is a more trustworthy outcome and we found some small effects.

Some small clear effects of pre-intervention motivation were observed on changes in well-being during the trial (0-4 months). However, these were all in the opposite direction to that proposed by SDT (Deci & Ryan, 2000), in that there were beneficial effects only on life satisfaction and vitality for those with low autonomous regulation and high external regulation. We suggest two explanations for these findings. First, the participants could not choose their training group because of the randomization procedure. It is likely that those autonomously motivated for exercise had some previous positive experiences from a particular type of exercise and therefore a preference for that exercise. Previous studies have shown that perceptions of autonomy are related to older adults' feelings of well-being (Kasser & Ryan, 1999). Thus, being randomized to a group could be more detrimental for well-being among those driven by autonomous regulations for training compared to those with more controlled regulations. Moreover, externally regulated individuals with feelings of pressure to enroll may have been positively surprised by the exercise trial. Secondly, the correlations between autonomous motivation and well-being indices at baseline indicate that those who were autonomously motivated

also reported higher well-being. Consequently, they may have been less amenable to change because of a ceiling effect.

Between cessation and follow-up (4-16 months) there were small reductions in all well-being indices, but they were trivial and unclear for negative affect. Moderator analyses indicated reductions in positive affect and increased negative affect for those high in external and introjected regulation at baseline. In contrast, those high in autonomous motivation maintained their well-being compared to those low in autonomous motivation. Others have reported that low self-determined motivation is related to dropping out of a sport (Ntoumanis, 2005; Pelletier et al., 2001; Sarrazin et al., 2002). Our findings support these studies, in that the intervention had small beneficial effects on change in physical activity for those autonomously motivated, while it was trivial for those with low autonomous motivation and negative for those with high extrinsic motivation. For the long-term changes (0-16 months), those with high extrinsic motivation were likely to report lower positive affect and physical activity. Hence, autonomous motivation seems beneficial for maintenance or even for increasing long-term effects of exercise, while extrinsic motivation could be detrimental. It may be that those with a high entry capital of autonomous motivation can better manage themselves after cessation of a trial, for example through better coping (Skinner & Edge, 2002) or higher intentions to continue exercise after cessation (Ntoumanis, 2005; Sarrazin et al., 2002). The trivial effect of continued exercise at the intervention site indicates that motivational regulations can explain long-term effects of an intervention independent of activity after cessation. This finding adds to the importance given by SDT to quality of motivation for understanding the outcomes of different behaviors. Whatever the

underlying explanation, our findings suggest that special attention should be given to extrinsically motivated older people to improve the outcome when they enroll for an exercise program. Autonomy support, competence support and involvement are three factors shown to enhance self-determined motivation in various domains (Deci & Ryan, 1991; Silva et al., 2010; Williams et al., 2004). These strategies could increase autonomous motivation and thereby promote longer lasting beneficial effects.

Limitations and future research

The sample size for the present study was based originally on a comparison of changes between training and control groups during the initial 16-week phase, when differences between the changes were expected to be moderate (Solberg et al., 2013). It is apparent from Table 3 that there were sufficient participants to provide clear outcomes within the training groups for all measures except physical activity, but comparisons of the changes between groups were unclear when the observed changes were similar. Some of the outcomes in the moderation analyses were also unclear. Future studies of long-term effects of motivation with different types of exercise should have approximately twice as many subjects to provide clear outcomes for most group comparisons and moderation effects.

Maintaining or increasing the level of physical activity in the long term is one of the goals of any program of supervised exercise, and physical activity is also an important predictor of well-being. Future studies of such programs should therefore include a more detailed assessment of physical activity than that provided by our simple frequency question.

Because the wait-list control group was offered training after the first four months of the trial, we had no control group for the follow-up. It could be argued that benefits of some kinds of exercise are reasonably well established, and therefore that anything other than a best-practice active control group is unethical in a study lasting more than a few months. Between baseline and follow-up, endurance training was clearly more beneficial than the other two forms of training, so we can reasonably assume that endurance training would be more beneficial than no training at all. Nevertheless, no exercise studies are blinded for treatment, so it is difficult to control for the expectancy effects of training on well-being (Oken et al., 2006).

Recommendations

Overall, there were few possibly harmful effects observed at 16 months follow-up with any of the training programs and with the positive physiological effects shown in other studies, exercise can be recommended for the elderly. Endurance training had better long-term outcomes than strength and functional training, making endurance a candidate for best-practice control in future follow-up studies investigating effects on well-being. One important overall aim of exercise trials is to increase the older adult's well-being and regular participation in physical activity. Exercise practitioners should identify older participants with low self-determined motivation or high controlled motivation and improve their quality of motivation, because these people are otherwise less likely to benefit from exercise.

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Table 1.

Subject characteristics and baseline values of dependent variables of participants in the three training groups who were assessed at 16 months (completers) and in those lost to follow-up (dropouts).

	Strength (n = 23)	Functional (n = 20)	Endurance (n = 19)	Lost to follow-up (n = 37) ^a
Characteristics				
Age (y)	75.8 ± 6.7	73.7 ± 3.9	73.7 ± 3.8	73.6 ± 3.3 ⁰
Body mass index (kg·m ⁻²)	26.7 ± 4.5	25.3 ± 3.8	26.7 ± 3.8	26.0 ± 3.7 [?]
Females (%)	61	55	68	78 ^{**}
Living alone (%)	44	40	58	60 [*]
College education (%)	61	37	42	35 [*]
Training attendance in 4-mo trial (%)	92 ± 6	84 ± 12	88 ± 7	86 ± 13 [?]
Autonomous motivation	4.1 ± 0.7	4.3 ± 0.5	4.1 ± 0.9	4.1 ± 0.7 [?]
Introjected motivation	2.9 ± 1.0	2.7 ± 1.1	2.8 ± 1.1	2.7 ± 1.2 [?]
External motivation	2.2 ± 0.9	2.2 ± 1.0	2.3 ± 1.3	2.3 ± 1.1 [?]
Dependent variables at baseline				
Life satisfaction (1 to 7)	4.9 ± 1.1	5.0 ± 1.0	4.8 ± 0.9	4.8 ± 1.3 [?]
Positive affect (1 to 5)	3.2 ± 0.7	3.4 ± 0.7	3.3 ± 0.7	3.3 ± 0.8 [?]
Negative affect (1 to 5)	2.0 ± 0.8	1.7 ± 0.8	1.9 ± 0.7	1.9 ± 0.7 [?]
Vitality at baseline (1 to 7)	4.9 ± 0.9	5.0 ± 1.2	5.0 ± 1.3	4.7 ± 1.5 ⁰
Physical activity (1 to 8)	5.0 ± 1.2	5.2 ± 1.4	5.0 ± 1.6	4.4 ± 1.8 [*]

Data are mean ± SD or proportion (%).

^aInferences shown are for comparison with all completers (n = 62).

^{*}possibly different, ^{**}likely different, ⁰possibly trivial, [?]unclear

Table 2.
Changes in indices of well-being in each group

Variable	Group	0 to 4 mo ^a	4 to 16 mo ^b	0 to 16 mo ^a
Life satisfaction	Strength	.09, ±.41 ⁰	-.22, ±.48 [†]	-.14, ±.49 [†]
	Functional	.32, ±.34 ^{**}	-.16, ±.38 [†]	.12, ±.30 ⁰⁰
	Endurance	.09, ±.42 ⁰	-.30, ±.35 ^{††}	-.18, ±.44 [†]
	All (total)	.17, ±.21 [*]	-.21, ±.21 [†]	-.05, ±.22 ⁰⁰⁰
Positive affect	Strength	.35, ±.42 ^{**}	-.45, ±.46 ^{††}	-.08, ±.56 [†]
	Functional	.65, ±.41 ^{****}	-.38, ±.69 ^{††}	.19, ±.62 [?]
	Endurance	.48, ±.59 ^{**}	-.18, ±.45 [†]	.30, ±.71 [*]
	All (total)	.49, ±.25 ^{****}	-.37, ±.28 ^{††}	.13, ±.34 [*]
Negative affect ^c	Strength	-.04, ±.51 ⁰	-.08, ±.51 [?]	-.18, ±.43 [*]
	Functional	.05, ±.44 ⁰⁰	.03, ±.56 ⁰	.10, ±.62 [†]
	Endurance	-.21, ±.42 [*]	-.08, ±.56 [?]	-.23, ±.54 [*]
	All (total)	-.08, ±.24 ⁰⁰	-.05, ±.33 ⁰⁰	-.13, ±.28 [*]
Vitality	Strength	.25, ±.35 [*]	-.57, ±.38 ^{††}	-.30, ±.40 ^{††}
	Functional	.28, ±.23 ^{**}	-.26, ±.42 [†]	.00, ±.28 ⁰⁰
	Endurance	.42, ±.40 ^{**}	-.12, ±.50 [†]	.27, ±.41 [*]
	All (total)	.31, ±.18 ^{**}	-.33, ±.23 ^{††}	-.02, ±.18 ⁰⁰⁰⁰
Physical activity	Strength	—	—	.01, ±.88 [?]
	Functional	—	—	.15, ±.48 [?]
	Endurance	—	—	.09, ±.48 [?]
	All (total)	—	—	.07, ±.29 ⁰⁰

Data are standardized effects ± 99% confidence limits. SD of change score in parenthesis. SD used for standardizing: life satisfaction, 1.0; positive affect, 0.7; negative affect, 0.7; vitality, 1.1; physical activity, 1.4

^aadjusted for baseline value

^badjusted for 4-mo value

^creduction is beneficial for negative affect

Explanation of superscripts denoting probabilistic inferences: ^{*}possibly beneficial, ^{**}likely beneficial, ^{***}very likely beneficial, ^{****}most likely beneficial, [†]possibly harmful, ^{††}likely harmful, ^{†††}very likely harmful, ⁰possibly trivial, ⁰⁰likely trivial, ⁰⁰⁰very likely trivial, ⁰⁰⁰⁰most likely trivial, [?]unclear.

Table 3.

Standardized effects of a between-subject difference of 2 SD of motivational moderators on change in dependent variables in all training groups combined.

Dependent	Moderator	0 to 4 mo ^a	4 to 16 mo ^b	0 to 16 mo ^b
Life satisfaction	Autonomous motivation	-.23, ±.41†	.17, ±.41 [?]	-.07, ±.43 [?]
	Introjected regulation	.17, ±.41 [?]	.05, ±.40 [?]	.17, ±.43 [?]
	External regulation	.31, ±.41**	-.08, ±.41 [?]	.22, ±.41*
Positive affect	Autonomous motivation	.12, ±.56 [?]	-.12, ±.57 [?]	-.26, ±.71 [?]
	Introjected regulation	.28, ±.50 [?]	-.28, ±.58 [?]	-.08, ±.69 [?]
	External regulation	-.05, ±.54 [?]	-.50, ±.55††	-.51, ±.65††
Negative affect ^c	Autonomous motivation	-.30, ±.49†	-.11, ±.60 [?]	-.32, ±.56 [?]
	Introjected regulation	-.23, ±.52 [?]	.44, ±.60**	.18, ±.58 [?]
	External regulation	-.35, ±.49††	.53, ±.59**	.26, ±.57 [?]
Vitality	Autonomous motivation	-.28, ±.38†	.45, ±.45**	.03, ±.43 [?]
	Introjected regulation	.28, ±.35*	-.05, ±.46 [?]	.14, ±.40 [?]
	External regulation	.29, ±.36*	-.24, ±.47 [?]	.13, ±.42 [?]
Physical activity	Autonomous motivation	—	—	.46, ±.58**
	Introjected regulation	—	—	-.08, ±.62 [?]
	External regulation	—	—	-.56, ±.57††

N = 62. Data are standardized effects ±.99% confidence limits.

^aadjusted for baseline value

^badjusted for 4-mo value of dependent

^creduction beneficial for negative affect

Explanation of superscripts denoting probabilistic inferences (mechanistic): †possibly positive, **likely positive, ***very likely positive, ****most likely positive, †possibly negative, ††likely negative, †††very likely negative, ††††most likely negative †possibly trivial, ††likely trivial, †††unclear.

Appendix A:

Approval letters from the Norwegian Social Science Data Services (NSD) and the Regional Ethical Committee (REK)



Jostein Hallén
Seksjon for fysisk prestasjonsevne
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Postboks 4014
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Vår dato: 08.07.2008

Vår ref: 18909 / 2 / SM

Deres dato:

Deres ref:

TILRÅDING AV BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 31.03.2008. Meldingen gjelder prosjektet:

18909	<i>Fysisk trening og eldre - "Senior-Løftet"</i>
Behandlingsansvarlig	<i>Norges idrettshøgskole, ved institusjonens øverste leder</i>
Daglig ansvarlig	<i>Jostein Hallén</i>

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

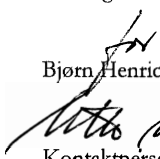
Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.


Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/forsk_stud/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, <http://www.nsd.uib.no/personvern/prosjektoversikt.jsp>.

Personvernombudet vil ved prosjektets avslutning, 31.12.2018, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen


Bjørn Henriksen


Siv Midthassel

Kontaktperson: Siv Midthassel tlf: 55 58 83 34
Vedlegg: Prosjektvurdering



Det legges til grunn at utvalget informeres om alle sider av prosjektet, jf. informasjonsskriv av 07.07.2008.

Prosjektmedarbeider og stipendiater Paul André Solberg og Nils Helge Kvamme skal benytte deler av materialet i sin doktorgrad og vil ha tilgang til datamaterialet på lik linje med daglig ansvarlig. Mastergradsstudentene Kristoffer Cummings og Vidar Andersen ved Norges idrettshøgskole skal skrive masteroppgave innenfor prosjektet. Ombudet legger til grunn at behandlingen som foretas er i henhold til det innmeldte hva gjelder formål, daglig ansvarlig, prosjektperiode og prosjektopplegg for øvrig.

Prosjektslutt er satt til 31.12.2018. Det planlegges en oppfølgingsstudie innen den tid. Utvalget er informert om dette og det vil bli innhentet nytt samtykke for oppfølgingsstudien. Dersom det ikke foreligger nytt samtykke til videre deltakelse/oppbevaring av personopplysninger innen 31.12.2018 vil datamaterialet anonymiseres. Anonymisering innebærer at verken direkte eller indirekte personidentifiserbare opplysninger, navneliste/koblingsnøkkel slettes og ev. indirekte personidentifiserbare opplysninger fjernes/tilstrekkelig kategoriseres.

Det må sendes egen melding for ev. oppfølgingsstudie i god tid før utvalget kontaktes og innen 31.12.2018. Det forutsettes at de nødvendige tillatelser foreligger før ev. oppfølgingsstudie igangsettes.

Ombudet legger til grunn at prosjektet er tilrådd av Regional komité for medisinsk og helsefaglig forskningsetikk (REK) før datainnsamling starter og ber om at kopi av tilrådingen ettersendes når denne foreligger. Ombudet har kun mottatt REKs tilråding av biobank. Det legges til grunn at opprettelse av forskningsbiobank er godkjent av Sosial- og helsedirektoratet, jf. biobankloven.



UNIVERSITETET I OSLO
DET MEDISINSKE FAKULTET

Professor Jostein Hallén
Norges Idrettshøgskole
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**Regional komité for medisinsk og helsefaglig
forskningsetikk Sør-Øst D (REK Sør-Øst D)**
Postboks 1130 Blindern
NO-0318 Oslo

Dato: 02.05.08
Deres ref.:
Vår ref.: 08/253d.2008/3637

Telefon: 22 85 05 93
Telefaks: 22 85 05 90
E-post: i.m.middelthon@medisin.uio.no
Nettadresse: www.etikkom.no

Fysisk trening og eldre ("Senior-Løftet")

Komiteen behandlet søknaden 16.04.08. Prosjektet er vurdert etter lov om behandling av etikk og redelighet i forskning av 30. juni 2006, jfr. Kunnskapsdepartementets forskrift av 8. juni 2007 og retningslinjer av 27. juni 2007 for de regionale komiteer for medisinsk og helsefaglig forskningsetikk.

Komiteen har ingen innvendinger mot opprettelse av forskningsbiobank og videresender søknaden om opprettelse av denne sammen med kopi av dette vedtaket til Helsedirektoratet for endelig godkjenning.


Vedtak:
Komiteen godkjenner at prosjektet gjennomføres i samsvar med det som fremgår av søknaden.

Vedtaket var enstemmig

Vennligst oppgi REKs referansenummer ved eventuelle henvendelser til sekretariatet.

Med vennlig hilsen

Stein A. Evensen (sign.)
Professor dr.med.
Leder


Ingrid Middelthon
Komitésekretær

Kopi:
• Helsedirektoratet

Appendix B:

Results from Paper I analysed with linear mixed modeling and magnitude-based probabilistic inferences

Table 4.

Net standardized effects of training on life satisfaction, positive affect and negative affect (training minus control) from baseline to Week 7 derived from models that included adjustment for baseline; also shown are standardized effects of baseline value within each group

Standardized effects of treatments compared to control (ES; ±99% CL)			
	Positive affect	Negative affect	Life satisfaction
Strength	.10, ±.41 [?]	-.41, ±.52 ^{**}	.14, ±.42 [?]
Functional	.27, ±.41 [*]	-.25, ±.52 [*]	.52, ±.40 ^{**a}
Endurance	.39, ±.53 ^{**}	-.33, ±.55 [*]	.35, ±.49 ^{**}
Standardized effects of baseline in each model (ES; ±99% CL)			
Strength	.01, ±.32 ⁰	.22, ±.36 [*]	-.18, ±.34 [?]
Functional	.20, ±.28 [*]	.42, ±.36 ^{**}	-.10, ±.27 [?]
Endurance	-.08, ±.40 ⁰	.16, ±.42 ⁰	-.10, ±.32 [?]
Control	-.32, ±.47 [†]	-.53, ±.26 ^{††}	-.19, ±.29 ⁰

Note. Data are standardized effects (ES) and 99% confidence limits (CL) for subjects assessed at baseline and Week 7 (n = 125).

Baseline SD of the dependent used for standardizing: PA=0.73, NA=0.70, SWLS=1.09

Effects of covariates are shown for 2 SD of the covariate.

Explanation of superscripts denoting probabilistic inferences: [?]possibly beneficial/positive, ^{**}likely beneficial/positive, ^{***}very likely beneficial/positive, ^{****}most likely beneficial/positive, [†]possibly harmful/negative, ^{††}likely harmful/negative, ⁰possibly trivial, [?]unclear (more data needed), ^a possibly beneficial compared to strength.

Table 5.

Net standardized effects of training on life satisfaction, positive affect and negative affect (training minus control) from baseline to Week 16 derived from models that included adjustment for baseline; also shown are standardized effects of baseline value within each group

Standardized effects of treatments compared to control (ES; ±99% CL)			
	Positive affect	Negative affect	Life satisfaction
Strength	-.03, ±.37 [?]	-.07, ±.59 [?]	-.16, ±.38 [†]
Functional	.21, ±.42 [*]	.11, ±.60 [†]	.01, ±.58 [?]
Endurance	.07, ±.53 [?]	-.10, ±.55 [?]	-.10, ±.36 [?]
Standardized effects of baseline in each model (ES; ±99% CL)			
Strength	-.29, ±.33 [†]	.08, ±.40 [?]	-.12, ±.41 [?]
Functional	-.11, ±.28 [?]	.16, ±.38 [?]	.00, ±.38 [?]
Endurance	-.26, ±.38 [†]	-.20, ±.42 [?]	.11, ±.43 [?]
Control	-.25, ±.18 ^{††}	-.25, ±.29 [†]	-.27, ±.21 ^{††}

Note. Data are standardized effects (ES) and 99% confidence limits (CL) for subjects assessed at baseline and Week 16 (n = 118).

Baseline SD of the dependent used for standardizing: PA=0.72, NA=0.68, SWLS= 1.08

Effects of covariates are shown for 2 SD of the covariate.

Explanation of superscripts denoting probabilistic inferences: [?]possibly beneficial/positive, ^{**}likely beneficial/positive, ^{***}very likely beneficial/positive, ^{****}most likely beneficial/positive, [†]possibly harmful/negative, ^{††}likely harmful/negative, ⁰possibly trivial, [?]unclear (more data needed).

Appendix C:

Main questionnaires

Exercise Causality Orientations (3 vignettes from ECOS; Rose et al., 2001, and 3 vignettes from GCOS; Deci & Ryan, 1985).

Below are different situations people might experience in relation to exercise. Every situation is followed by three alternatives (a, b and c), which represent different ways of reactions. There are no right or wrong answers. Please imagine every situation, and mark on every scale to what degree the response are suitable for you in the given situation. Use the following scale: 1 (very likely) to 7 (very unlikely).

ECOS (responses from GCOS)

- 1) You are beginning a new exercise programme. What is the first question that comes to your mind?
- What if I can't manage this?
 - I wonder if this is going to be interesting?
 - I wonder what the others (they) want me to do?

ECOS

- 2) In order to monitor how well you are doing in exercise you are like to want:
- To be given a lot of praise and encouragement from others
 - To evaluate your own performance and provide yourself with positive feedback
 - To just hope that what you are doing is correct

ECOS

- 3) During an exercise session, how hard you are working out is likely to be governed by:
- The intensity you have been told to exercise at
 - What everybody around you is doing
 - How you are feeling whilst exercising at the intensity you choose

GCOS (12 item version)

- 4) You have just received the results of a test you took, and you discovered that you did poorly. Your initial reaction is likely to be:
- "I can't do anything right" and feel sad
 - "I wonder how it is I did so poorly", and feel disappointed
 - "That test doesn't show anything", and feel angry

GCOS (12 item version)

- 5) You are about to start a new training regime. Your most important consideration is likely to be:
- Whether you can do the exercise without getting over your head
 - How interested you are in this type of training
 - What other people want me to do (IKKE ORIGINAL)

GCOS (12 item version)

- 6) You are invited to exercise where you know few people. As you look forward to this, you are likely to (expect):
- You'll try to fit in whatever is happening in order to not look bad
 - You'll find some people with whom you can relate
 - You'll probably feel somewhat isolated and unnoticed

(Self-constructed item)

- 7) Your progress in relation to exercise is most likely dependent on:
- a) Your effort in training and your attitude towards exercise
 - b) What the instructor tells you to do
 - c) I don't think I can have much progress in exercise

The Behavioural Regulation in Exercise Questionnaire (BREQ; Mullan et al., 1997)

Why do you want to exercise?

External regulation:

- I exercise because other people say I should
- I take part in exercise because my friends/family/spouse say I should
- I exercise because others will not be pleased with me if I don't
- I feel under pressure from my friends/family to exercise

Introjected regulation:

- I feel guilty when I don't exercise
- I feel ashamed when I am not exercising
- I feel like a failure when I haven't exercised in a while
- I feel bad about my self when not exercising (TRSQ)

Identified regulation:

- I value the benefits of exercise
- It's personally important to me to exercise
- I think it is important to make the effort to exercise
- It's personally important to me (TRSQ)

Intrinsic regulation:

- I exercise because it's fun
- I enjoy doing exercise
- I find exercise a pleasurable activity
- I get pleasure and satisfaction from doing exercise

Responses were given on a Likert scale from 1 (not true for me) to 5 (very true for me).
Note that the original version has a 0 to 4 Likert scale with similar response options.

The Perceived Competence Scale (PCS; Williams & Deci, 1996)

Please respond to each of the following items in terms of how true it is for you with respect to physical activity. Use the scale 1 (not at all true) to 7 (very true).

1. I feel confident in my ability to be physically active.
2. I am capable of being physically active.
3. I know how to be physically active.
4. I feel able to meet the challenges of being physically active.

This is a version of perceived competence scale that is adapted to exercise.

The Health Care Climate Questionnaire (HCCQ; Williams et al., 1996)

This questionnaire is related to your experience with the instructor. All your responses are confidential, and please respond as honest as possible on all items. Your answers are not to be related to which instructor it is about. Use the following scale: 1 (strongly disagree) to 7 (strongly agree).

1. I feel that my instructor provides me choices and options
2. I feel understood by my instructor
3. My instructor conveyed confidence in my ability to do well in exercise
4. My instructor encouraged me to ask questions
5. My instructor listens to how I would like to do things
6. My instructor tries to understand how I see things before suggesting a new way to do things
7. I feel a lot of trust in my coach
8. I feel that the coach cares about me as a person

The last two items were added from the 15-item version to the well-validated 6-item version because a ceiling effect has been observed in other studies using the short-version (e.g., Fortier et al., 2007). In addition, these two items may take more time to affect.

Basic Need Satisfaction in Exercise Scale (BPNES; Vlachopoulos & Michailidou, 2006)

Please indicate on the scale ranging from 1 (not at all true) to 7 (very true for me) how these items correspond with your feelings when training.

Need for Competence

- I feel I have been making a huge progress with respect to the end result I pursue
- I feel that I execute very effectively the exercises of my training program
- I feel that exercise is an activity which I do very well
- I feel that I can manage with the requirements of the training program I am involved

Need for Autonomy

- The exercise program I follow is highly compatible with my choices and interests
- I feel very strongly that the way I exercise fits perfectly the way I prefer to exercise
- I feel that the way I exercise is definitely an expression of myself
- I feel very strongly that I have the opportunity to make choices with respect to the way I exercise

Need for Relatedness

- I feel extremely comfortable when with the other exercise participants
- I feel that I associate with the other exercise participants in a very friendly way
- I feel there are open channels of communication with the other exercise participants
- I feel very much at ease with the other exercise participants

Note that the original response format is ranging from 1 (totally disagree) to 5 (very strongly agree).

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988)

Please indicate on the scale below to what degree you have experienced the following feelings the past 4 weeks on a scale ranging from 1 (very little) to 5 (very much).

Positive Affect:

- Excited
- Enthusiastic
- Alert
- Inspired
- Determined
- Active

Negative Affect:

- Upset
- Distressed
- Afraid
- Nervous
- Scared
- Irritable

The items are similar to the short-version (10 items) validated by Kercher (1992), Hillerås et al. (1998) and used in the NorLAG study (2006). The additional two items (active and irritable) were included from the 20-item version after the pilot.

The Satisfaction With Life Scale (SWLS; Pavot & Diener, 1993)

Please indicate to what degree each item fits with how you feel in general on a scale ranging from 1 (strongly disagree) to 7 (strongly agree)

1. In most ways my life is close to my ideal
2. The conditions in my life are excellent
3. I am satisfied with my life
4. So far I have gotten the important things I want in life
5. If I could live my life over, I would change almost nothing

The Subjective Vitality Scale (SVS; Ryan & Frederick, 1997)

Please respond to each of the following statements by indicating the degree to which the statement is true for you in general in your life on the following scale: 1 (not true at all) to 7 (very true).

1. I feel alive and vital.
2. I feel I have surplus energy
3. I have energy and spirit.
4. I look forward to each new day.
5. I nearly always feel alert and awake.
6. I feel energized.

This is the 6 item version validated by Bostic et al., (2000), where the reversed item (“I don’t feel very energetic”) is removed. Note that item 3 (“Sometimes I feel so alive I just want to burst”) was replaced with “I feel I have surplus energy”.

