

Objectively Measured Physical Activity in Home Guard Soldiers During Military Service and Civilian Life

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ABSTRACT Soldiers are encouraged to be physically active, and thereby maintain or increase their fitness level to meet job-related physical demands. However, studies on objectively measured physical activity (PA) in soldiers are scarce, particular for reserve soldiers. Hence, the aim of this study was to present PA data on Norwegian Home Guard (HG) soldiers. A total of 411 HG soldiers produced acceptable PA measurements (SenseWear Armband Pro₂) during civilian life, of which 299 soldiers also produced acceptable data during HG military training. Reference data on total energy expenditure, metabolic equivalents, steps per day, and minutes of PA in three different metabolic equivalent categories are presented. The HG soldiers produced more minutes of moderate PA during HG military training compared to civilian life, but less vigorous and very vigorous PA. Furthermore, HG soldiers were more physically active during civilian week days compared to weekend days. The presented reference data can be used for comparisons against other groups of soldiers. Our data indicate that aerobic demands during HG military training were not very high. Promoting PA and exercise could still be important to ensure HG soldiers are physically prepared for more unforeseen job tasks.

INTRODUCTION

Physical fitness and exercise training are emphasized in armed forces around the world since military service can be physically challenging.^{1,2} Studies show that general exercise training can enhance military-related physical work capacity in soldiers,³ while high levels of leisure time physical activity (PA) has been linked with more favorable aerobic fitness levels and body composition in officers.⁴ Exercise training, PA, and fitness are also valued in the Norwegian Armed Forces, illustrated by regulations allowing all officers to exercise 2 hours per week during work hours and by the obligatory annual fitness tests for all officers and full-time soldiers. However, the focus on exercise and fitness has traditionally not applied to part-time reserve soldiers and officers within the Home Guard (HG).

The HG is the largest branch within the Norwegian Defense Forces in terms of number of personnel (45,000 soldiers and officers). The main function of the HG is to protect the local territory and population during warfare and civilian crisis. The HG consists of soldiers and officers selected from a pool of men (and a few women) who have completed their obligatory military service year or officer training. Service in the HG is mandatory for the selected men, whereas women volunteer. The selection criteria may vary among different HG districts. About 93% of HG soldiers belong to the Regular HG force, whereas the remaining 7% volunteer for a more comprehensive service in the Rapid Reaction HG force

(the current study does not include Rapid Reaction HG force soldiers, but this force was described previously⁵). The Regular HG force soldiers are typically called for military training from 3 to 7 days per year. Thus, except for the few days of military training, HG soldiers live a civilian life. There are no fitness requirements to serve in the Regular HG force, and no military-organized exercise training exists for Regular HG soldiers. Thus, each individual is responsible for obtaining necessary “fitness for duty” during his or her civilian life.

Little attention to exercise and fitness within the HG may reflect anticipated low job-related physical demands. A main task for Regular HG soldiers is to protect important military and civilian objects (e.g., buildings, roads, bridges, and VIPs). Such stationary work is usually not very physically challenging. Yet, the HG also assists professional military forces, the police, or other civilian authorities during military crises, natural disasters, or rescue operations. The physical demands during this type of work may be higher. Until now, neither physical demands nor PA/fitness levels have been investigated in Norwegian HG soldiers. International studies in this field are also scarce. We have identified two previous studies evaluating physical demands in reserve soldiers; however, both investigated job tasks less relevant to our HG soldiers.^{6,7} A few studies on fitness levels of reservists or National Guard soldiers and officers exist,^{8–10} but these soldiers and officers are not always comparable to our HG personnel (e.g., recruited differently). Previous international studies on PA in reserve forces are also very limited, mainly presenting incomplete descriptions of self-reported PA.^{9–11} Such PA questionnaires are often considered less valid than objective measurement techniques.¹² So far, objectively measured PA has primarily been reported on full-time soldiers in small-scale studies with other research aims than reporting population values of PA.^{13–15} Accordingly, previous

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international literature has recommended increased research into health, physical fitness, and readiness of reservists.^{8,16}

Based on the aforementioned research gaps, we initiated a study on PA and fitness levels in Norwegian HG soldiers. The fitness reference data were recently described in a separate article.⁵ In this article, we present reference values on objectively measured PA levels in Regular HG force soldiers, describe how PA levels differed between civilian life and HG military training, and discuss whether HG soldiers' fitness level match the physical demands measured during HG training.

METHODS

Study Design and Ethics

This study is a descriptive cross-sectional study with a cluster-randomized sampling procedure. The study was approved by the Regional Committee for Medical and Health Research Ethics and the Norwegian Social Science Data Services. Subjects volunteered by giving their written consent after receiving written and oral information about the study.

Subjects

The sampling procedure started by allocating all 13 HG districts into five groups, based on geographical location: North, South, East, West, and Mid-Norway. One HG district from each stratification group was randomly selected to participate in the study. Each of the five HG districts was visited twice between 2006 and 2009 during scheduled military HG training. Between two and six troops were randomly selected to participate at each visit. In total, Regular HG soldiers from 34 troops participated in the study.

All available soldiers and officers ($n = 823$) in the selected 34 troops received information about the study and were invited to participate. All prospective participants were men. Ninety-four subjects (11%) declined to participate (Fig. 1). Among the 729 soldiers who initially volunteered for the study, 61 later declined to wear the PA monitor. Since the number of volunteer subjects in some troops outnumbered the available monitors, 128 randomly selected soldiers were not offered monitors. Among the soldiers who received the monitor, data from 19 subjects (all from 1 troop) were later excluded because of a suspected inappropriate randomization. In addition, some monitors were not returned, and some data were lost because of technical errors. Ninety-four soldiers did not wear the monitor for a sufficient amount of time. Thus, 411 soldiers produced acceptable monitor data during civilian life, of which 299 subjects also produced acceptable data during HG military training. Among the 411 HG soldiers, 42 (10%) reported being reserve officers, whereas the rest were all private (compulsory enlisted) soldiers. We have analyzed officers and soldiers together and will use the term "HG soldiers" for the group combined.

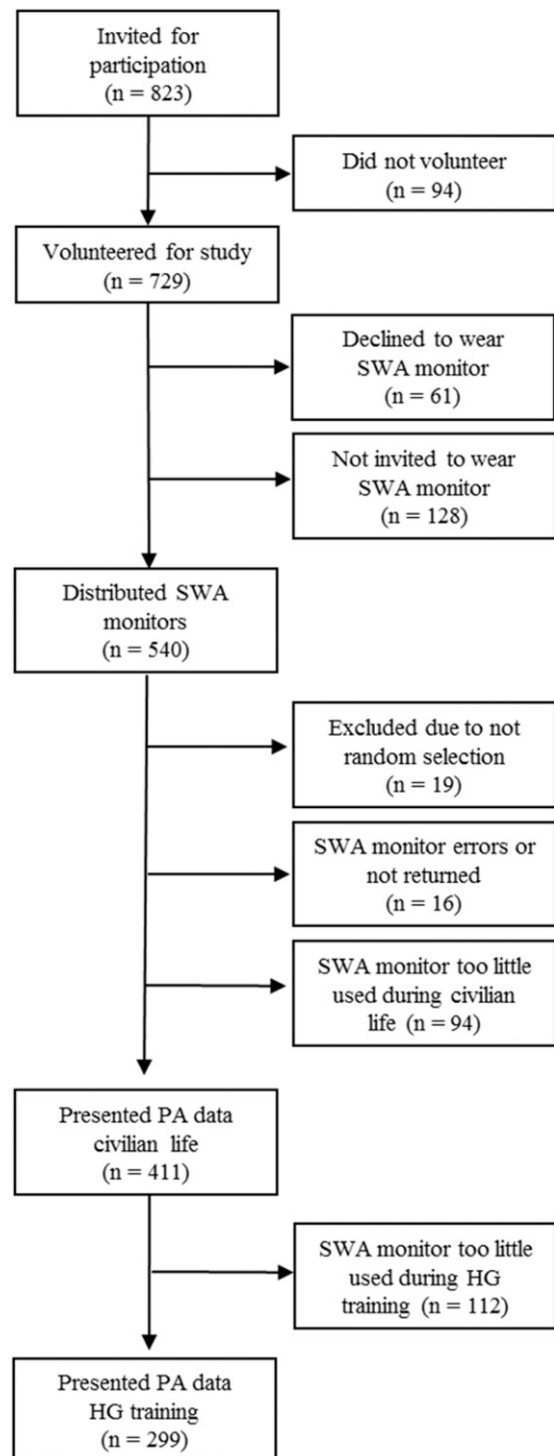


FIGURE 1. Flowchart of participation with included and missing physical activity monitor data.

Mean (SD) height, body mass, and body mass index were 180.5 (7.0) cm, 84.8 (13.1) kg, and 26.1 (3.7) kg·m⁻², respectively, among the 411 soldiers with accepted PA measurements. Mean age was 33 (5) years, with range from 21 to 44 years.

Procedures

Body mass and height were measured using a calibrated combined digital scale and stadiometer (model 708; Seca, Hamburg, Germany) to the nearest 0.1 kg and 5 mm, respectively.

SenseWear Armband (SWA) Pro₂ monitors (BodyMedia, Pittsburgh, Pennsylvania) were used to measure PA. The SWA monitor measures heat flux, galvanic skin response, skin- and near-body temperature, and additionally includes a 2-axis accelerometer.¹⁷ Validity of this monitor (including the software version we used) has previously been investigated in civilian and military adults.¹⁸ The SWA monitor was distributed during HG training, immediately after physical testing was completed. The subjects were instructed to wear the monitor for all the remaining HG training days, and then for an additional 7 consecutive civilian days. Some subjects forgot to take the monitor off at the correct date and may have a few extra “wear days.” These extra days have been included in the analysis. Some subjects were included in the study at the final day of their HG training; thus, no data on PA during military training was obtained in these subjects.

The subjects received thorough explanations (visual, oral, and written) on how to use the SWA monitor. The monitor was worn on the upper right arm at the triceps muscle and removed only during water activities. At the end of the measurement period, the monitor was returned by prepaid mail. The HG soldiers also returned a short questionnaire where they indicated the specific days they had worn the monitor during HG training and civilian life, respectively.

Data Processing

The SWA data were collected at 1-minute intervals and downloaded using Innerview Professional Software v. 5.1 (BodyMedia). The software algorithms calculate values for several PA variables. We present data for the following six variables: total energy expenditure (TEE), number of steps, metabolic equivalents (METs),¹⁹ and time in moderate (3–6 METs), vigorous (6–9 METs), and very vigorous (>9 METs) intensity PA.

A minimum of 20 hours of monitor wear time per day was treated as a valid day, whereas days with <20 hours of wear time were excluded from the analysis. Furthermore, inclusion criteria for an accepted civilian measurement period were at least 2 valid week days and 1 valid weekend day. Inclusion criteria for an accepted HG training measurement period were at least one valid HG training day (week day or weekend day) in addition to an accepted civilian measurement period. The day a soldier finished his HG training period and returned to civilian life was excluded from the analysis.

Data have been processed separately for civilian week days, civilian weekend days, and HG military training days. Mean values per day (for all six PA variables) were calculated from each subject’s valid measurement days. We also calculated weighted mean values from civilian week days

and civilian weekend days combined. For the weighted mean data, the 5 week days (Monday to Friday) contribute 5/7 to the generated weighted mean value, whereas the 2 weekend days (Saturday and Sunday) contribute 2/7.

Statistical Analysis

All outcome variables, including their residuals, were checked for normality by visual inspections of data distribution plots. Normally distributed data are presented as mean with 95% confidence interval (CI) or SD, whereas skewed data are presented as median with 25th to 75th percentiles. Data on time in moderate, vigorous, and very vigorous intensity PA were skewed, in addition to including values of zero. Thus, square root transformations were performed before analyzing these data for differences between conditions. The data were subsequently back-transformed before being presented. We did not calculate CIs for differences for the back-transformed data, according to suggestions by Bland and Altman.²⁰ Differences in PA level between HG training and civilian life, and between civilian week days and weekend days, were analyzed with a linear mixed-effect model with restricted maximum likelihood approach and least significant difference CI adjustments. Thus, the mean difference values are based on estimated marginal means. Since data from the same individuals were compared over different time points, the data were analyzed as repeated measurements. The mixed model allowed us to account for the cluster randomized design, using troop as a random effect. The linear mixed-effect model was also used for the missing data analysis. Statistical analyses were performed in SPSS (version 21; IBM, Armonk, New York). A probability (*p*) of <0.05 was considered statistically significant.

RESULTS

The mean (SD) number of days with accepted SWA wear time during civilian week days and weekend days was 4.3 (1.0) and 2.0 (0.6) days, respectively. The corresponding value during HG training was 1.4 (0.6) days. The mean (SD) wear time per day was 23:33 (00:25), 23:29 (00:39), and 23:45 (00:24) hours : minutes during the three mentioned time periods, respectively.

Civilian week days and weekend days PA data are presented separately in Table I. Among the HG soldiers with accepted SWA data during civilian life, the values for five out of six PA variables were significantly higher during week days compared to weekend days. The cumulative relative frequencies of the PA variables (for weighted mean of civilian week days and weekend days combined) are presented in Figure 2. The median time spent in ≥moderate intensity PA from the weighted mean of civilian week days and weekend days was approximately 3 hours (179 minutes) per day. This includes 4 minutes per day with very vigorous PA (>9 MET).

TABLE I. Physical Activity Characteristics During Civilian Week Days (Monday to Friday) and Weekend Days (Saturday and Sunday) in 411 Home Guard Soldiers

Days of the Week	TEE (Kcal)	Steps (Number)	METs (Ratio Score)	Moderate PA (Minutes)	Vigorous PA (Minutes)	Very Vigorous PA (Minutes)
Week Days	3,548 (3,472–3,623)	10,448 (10,037–10,859)	1.78 (1.74–1.82)	153 (105–239)	17 (8–33)	3 (1–8)
Weekend Days	3,382 (3,309–3,454)	9,209 (8,780–9,638)	1.70 (1.66–1.74)	140 (93–209)	15 (5–29)	2 (0–7)
Difference (95% CI)	166 (64–268)	1,251 (628–1,874)	0.08 (0.03–0.13)	21	2	1
<i>p</i> Value	0.001	<0.001	0.002	0.001	0.053	0.029

TEE, total energy expenditure; METs, metabolic equivalents; PA, physical activity; vig, vigorous. TEE, steps, and METs are presented as mean (95% CI) per day, whereas the other variables are presented as median (25th to 75th percentiles). Differences are based on estimated marginal means from the linear mixed-effect model and reflect week days minus weekend days. The 95% CI, with the CIs adjusted for the cluster sampling, are only given for TEE, steps, and METs.

Comparisons of PA characteristics between HG military training and civilian life (weighted mean of week days and weekend days combined) are shown in Figure 3. Data are based on the 299 soldiers who produced valid SWA data during both HG training and subsequent civilian life. The

HG soldiers spent significantly more time in moderate intensity PA during HG training compared to civilian life, but less time in vigorous and very vigorous PA. There was no difference in mean TEE, steps, or METs between HG training days and civilian life days.

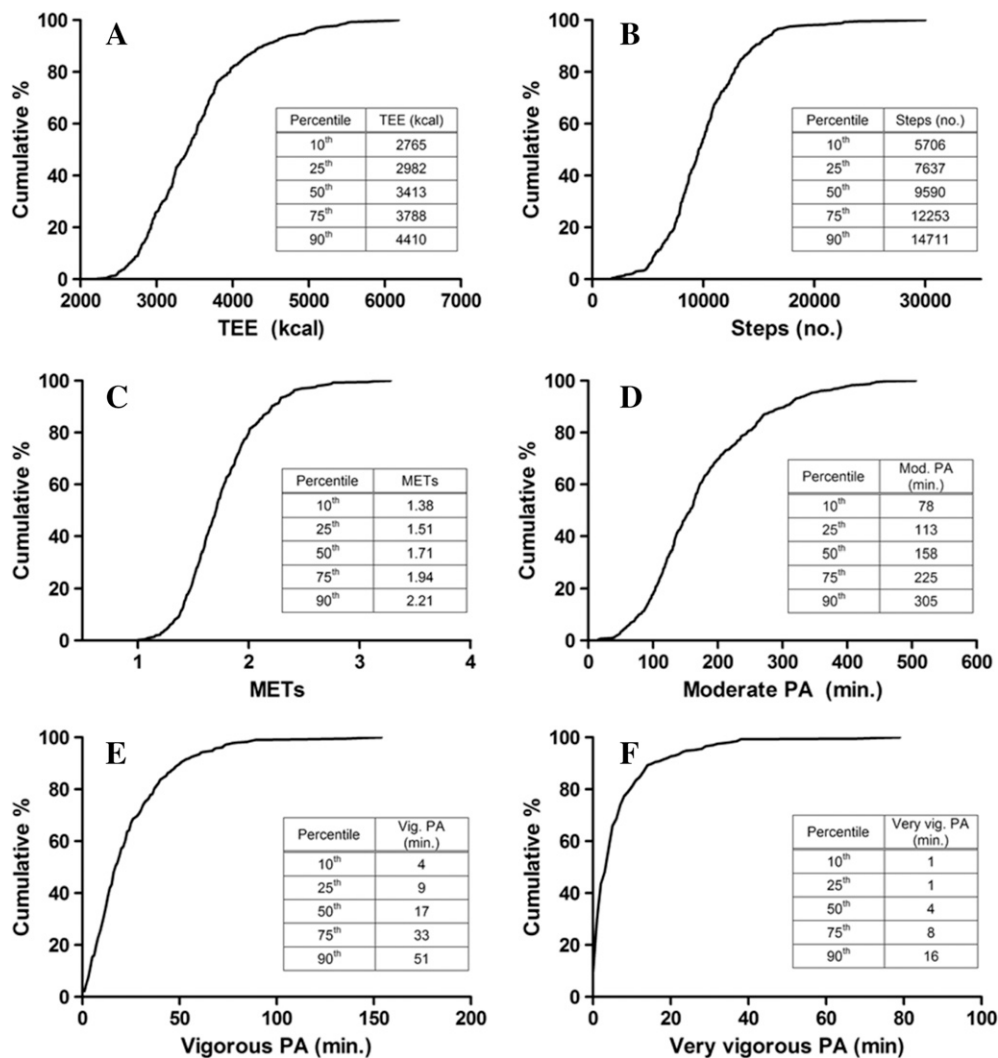


FIGURE 2. Cumulative relative frequency (%) for physical activity (PA) variables in 411 Home Guard (HG) soldiers during civilian life. The data represent weighted mean of week days and weekend days combined (average per day). (A) total energy expenditure (TEE), (B) total steps, (C) metabolic equivalents (METs), (D) time in moderate PA (3–6 METs), (E) time in vigorous PA (6–9 METs), and (F) time in very vigorous PA (>9 METs).

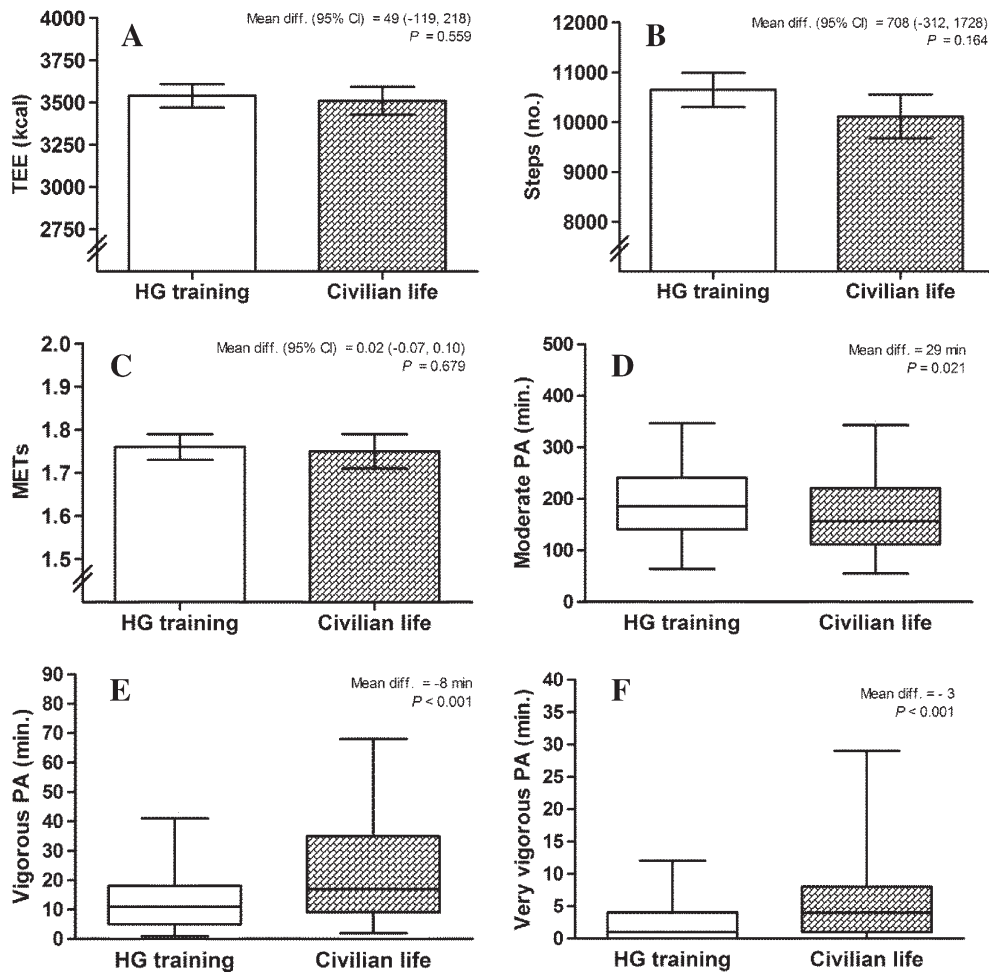


FIGURE 3. Comparison of physical activity (PA) characteristics in 299 Home Guard (HG) soldiers during HG military training and civilian life. The data represent weighted mean of week days and weekend days combined (average per day). Bars in (A) (total energy expenditure; TEE), (B) (steps) and (C) (metabolic equivalents; METs) represent mean (95% CI). In (D), (E), and (F) the boxes cover the range from 25th to 75th percentile, the whiskers cover the range from 5th to 95th percentile, while the horizontal line in the box indicate median. The text presents mean difference (included 95% CI for A, B, and C) between PA during HG training compared to civilian life, with corresponding p values.

Of the initial 729 HG soldiers who volunteered for the study, only 411 (56%) produced valid civilian SWA data. However, the 318 soldiers with missing civilian SWA data did not differ on age ($p = 0.180$), height ($p = 0.422$), body mass ($p = 0.784$), or body mass index ($p = 0.589$) from the 411 soldiers with valid civilian SWA data. The 112 soldiers with missing SWA data during HG training did not differ significantly on age, anthropometrics, or any SWA data gathered during civilian life, compared to the 299 soldiers with valid SWA data during both civilian life and HG training.

DISCUSSION

The current study presents reference data on objectively measured PA in Norwegian HG soldiers during civilian life and HG military training. The data collected during civilian life display the general PA level of the subjects, whereas data collected during HG training indicate the aerobic-related physical demands during HG military service. In civilian studies, PA

levels are often linked to health. In the present discussion we will rather focus on the link between PA, aerobic fitness, and military work demands.

PA During Civilian Life

HG soldiers live a civilian life, except for the few days of HG training every year. Thus, the PA and exercise carried out during civilian life have a much larger impact on HG soldiers' fitness level compared to activity carried out during HG training. Consequently, the measured PA during civilian life might indicate whether the amount of exercise is sufficient to obtain (or maintain) necessary aerobic fitness for military work.

Our results demonstrate that HG soldiers are physically active approximately 3 hours per day (during civilian life) with an intensity of ≥ 3 METs. The majority of this time is spent in the "moderate" (3–6 METs) intensity zone. Since 1 MET is commonly set at $3.5 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ in oxygen

consumption (VO_2),²¹ it follows that this MET zone covers a VO_2 range from approximately 11 to 21 $\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. Our previously published data showed that the HG soldiers had an average estimated peak oxygen uptake ($\text{VO}_{2\text{peak}}$) of 50 $\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$.⁵ Consequently, the 3 to 6 MET zone corresponds to an intensity of approximately 21 to 42% of $\text{VO}_{2\text{peak}}$ for the average fit HG soldier. This exercise intensity does not seem to increase aerobic capacity in moderately trained individuals, or at least higher intensity exercise will be more effective.²² The “vigorous” (6–9 METs) zone corresponds to an intensity of approximately 42 to 63% for the average fit HG soldier, whereas the “very vigorous” (>9 METs) zone corresponds to activity above 63% intensity. The latter zone probably yields the most effective aerobic exercise training in the studied HG soldiers. The soldiers produced 4 minutes PA (median value) per day in >9 METs, which corresponds to about half an hour per week. This may not seem like much, but is apparently sufficient to produce a mean $\text{VO}_{2\text{peak}}$ of 50 $\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (probably considered a good aerobic fitness level for reserve soldiers⁵). Still, HG soldiers in general could benefit from more exercise with high intensity to maintain or increase their maximal aerobic capacity.

The studied HG soldiers were less physically active during civilian weekend days compared to week days. A large number of HG soldiers and officers reported their civilian work to have a substantial physical component (data not shown). This might be one reason why PA was higher during the week days. Higher PA levels during week days have also previously been reported in Norwegian children/adolescents and in U.S. adults.^{23,24}

Our data can be compared to several studies on objectively measured PA in civilian adults.²⁵ Hansen et al²⁶ measured PA by accelerometers in >1,200 civilian Norwegian men aged from 20 to 64 years. They showed that 22% of the men achieved $\geq 10,000$ steps per day, which is sometimes recommended as a minimum level related to health.²² In comparison, 44% of our HG soldiers reached this cutoff value for steps during civilian life. In addition, Hansen et al reported a mean value of 37 minutes per day of PA ≥ 3 METs, which is remarkably lower than the approximately 3 hours per day found in this study. However, comparing PA values from different studies might be limited by several factors, such as the use of different PA monitors or different data processing methods.²¹ We have identified some civilian studies which used the same monitor as in our study,^{27–29} but comparisons to our data might still be difficult since different SWA software versions could produce different values.³⁰

PA During HG Training

Several previous studies have demonstrated high physical demands during military training,^{13,31,32} and it is claimed that the physical demands placed on modern soldiers continue to be substantial.¹ However, our study found that PA

level during HG training was not very different from the soldiers' PA level during civilian life. In fact, more high intensity PA was performed during civilian life compared to HG training, whereas the opposite was evident for moderate intensity PA. Thus, the aerobic fitness demands placed on Norwegian HG soldiers seems less than what is typically anticipated for soldiers in general.

Previous studies reporting PA levels in HG soldiers or reservists are scarce, with the exception of Talbot et al³³ who measured steps per day in male and female U.S. National Guard soldiers. Our HG soldiers walked more steps per day compared to the U.S. reserve soldiers. However, the groups are not directly comparable since the U.S. soldiers consisted of selected soldiers who all had failed the 2-mile run test, which might reflect lower PA level compared to the average U.S. National Guard soldier.

More PA data are available for nonreserve soldiers. Tharion et al³⁴ have presented several studies reporting TEE in various types of soldiers from around the world, all measured by doubly labeled water (DLW) during military field training and life in garrison. Mean TEE for the combined group of 424 male soldiers was $4,610 \pm 650$ kcal per day, which is approximately 30% higher than estimated TEE in our soldiers during HG training and civilian life. Finnish conscripts during basic training, U.S. Marine soldiers during a winter military training course, and Norwegian Army cadets during a 7-day field exercise also produced higher DLW–TEE values compared to our HG soldiers.^{15,35,36} However, these measurements took place during strenuous military field training, which probably do not reflect PA levels during regular military life in garrison.

Are HG Soldiers “Fit for Duty”?

Our previously published $\text{VO}_{2\text{peak}}$ values in HG soldiers indicated that members of this reserve force have a pretty good aerobic fitness level, particularly considering age and military training background.⁵ Regular HG soldiers primarily carry out rather motionless work, with relatively low requirements for aerobic fitness. Yet, HG soldiers may also face unknown job tasks, for which they do not train during HG training. For example, HG soldiers are sometimes called out during mountain rescue operations or during natural disasters. Our PA measurements during HG training did not include this more unforeseen work, which may include higher physical requirements. Hence, we conclude that most HG soldiers have sufficient aerobic fitness for the preplanned tasks designated to the Regular HG force, although other less defined aspects of the work may be more restricted by the soldiers' physical capacity.

Study Strengths and Limitations

This appears to be the first study of its scale on objectively measured PA in reserve soldiers. We objectively measured PA, which is generally considered more valid than self-reported

methods.¹² We used a PA monitor that is validated in several studies, showing good agreement for estimated TEE against indirect calorimetry¹⁸ and DLW.³⁷ The subjects produced a high monitor wear time, and data were gathered during both civilian life and HG training. A representative, geographically diverse sample was secured.

However, the study also had some limitations. Lack of compliance or missing data in different stages of the study might influence the results. About 50 to 95% (median 70%) of the soldiers met for the obligatory HG training in the five included districts, according to district officers. The remainder obtained permission to refrain from the annual training because of civilian work, travel, or sickness. According to the district officers these soldiers are probably missing at random, but we have no data to verify this. In addition, some soldiers declined to participate in the study and some did not produce valid measurements. We do not know whether these subjects differ in PA level compared to the subjects who volunteered, but the missing data analysis indicates that these data are missing at random.

This article only describes PA for Regular HG force soldiers. Ideally, PA data for Rapid Reaction HG soldiers would also have been presented. Four troops of Rapid Reaction HG soldiers were initially included in the study. For various reasons, only 12 soldiers produced accepted PA data during both civilian life and during HG training, which is too low to be presented as reference data.

The PA levels during civilian life were monitored the week after the HG annual training. It is possible that the HG training influenced the level of PA on the successive week (carryover effect). Soldiers who experienced physically hard work during the HG training might be less physically active the days after the HG training, and vice versa for personnel who experienced light work during the HG training. Moreover, PA level may be temporarily modified due to being monitored (Hawthorne effect). Yet, we do not have valid evidence for (or against) any modified behavior in the monitoring period. From international literature, the empirical evidence of modified behavior due to being monitored is equivocal and scarce.³⁸

A thorough analysis of job-related physical demands should ideally include both a task and demand analysis.³⁹ The current study only included an analysis of the aerobic-related demands. HG training usually reflects the key tasks for this group; yet, the actual content of the HG training carried out during this study period was not recorded.

Although, it is claimed that the SWA monitor predicts TEE more accurately than the more frequently used waist-mounted accelerometers,⁴⁰ several other studies have shown that the SWA underestimates energy expenditure for high intensity activities.^{18,41} Moreover, a previous validation study of the SWA showed that TEE and MET were underestimated during resistance training with external weight.⁴² We did not register the HG soldiers' carried load during military training, but they always wore their combat uniform, and sometimes

moved around with backpack, weapon, etc. This external load might lead to underestimated PA figures during HG training. Finally, it must also be emphasized that the SWA monitor is designed to measure aerobic-related PA only. Physical work that taxes other fitness components (like maximal strength) is not reflected in the SWA data.

CONCLUSIONS

In the current study, we have described the PA level of Norwegian HG soldiers during military training and civilian life. The presented data can be used as reference values for PA in reserve soldiers and are particularly valuable as such data are scarce or nonexistent. In their civilian life, HG soldiers carried out moderate or higher intensity PA for approximately 3 hours per day. Yet, the majority of this PA was within the moderate range (3–6 METs), which is not effective aerobic exercise training. Our data also indicated that the aerobic demands were relatively low during HG training, and less vigorous and very vigorous PA were carried out during HG training compared to civilian life. Accordingly, taking previously published VO_{2peak} data into account, most of the HG soldiers appeared to have a sufficient aerobic capacity to successfully carry out predefined tasks. We must, however, acknowledge that our study design does not give a complete picture of the physical demands placed on HG soldiers during military training and real-scenario work. Increased PA and exercise could therefore ensure HG soldiers are better physically prepared also for completing the less-frequent (but critical) job tasks. Thus, promoting PA and exercise among HG soldiers could still be valuable.

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