eTable 1. Studies showing a relationship between athlete body composition and performance in sport. Studies are sorted 1) by the most prevalent sport category by taxonomy (49); and 2) by year of publication. Values are mean (SD) if not otherwise stated. See search term combination, inclusion- and exclusion criteria in supplementary material.

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
Endurance sport	Effect of heavy strength training on thigh muscle cross-sectional area, performance determinants, and performance in well-trained cyclists (61). 2009	Investigate the effect of heavy resistance training on BC and performance in cyclists. Endurance + RT *versus* endurance only	Cycling, Highly trained. T3. Male (n=18) & female (n=2) Interventional	28.5y (2)	MRI S.P.: Diet, physical activity, technical details on positioning	*Not described*	*Not described*	Endurance + RT increased strength and CSA in thigh muscle by 4.6% (0.5), without change in BM, and increased PO in Wingate 30s by 9.4% (2.9).
	Skin-fold thickness and training volume in ultra-triathletes (51). 2009	Investigate which of anthropometry or training was of more importance for a successful finish in a Triple Iron triathlon	Triathlon, recreational. T2. Male (n=29) Prospective, observation	42.1y (8.1)	Skinfold[4] S.P.: *Not described*	81.8mm (23) 15.3% (3.2)	*Not described*	33% of total race time was explained by SSK (positively *associated*), with no effect from weekly training volume. SSK was not associated with swim- or cycle time; only run time.
	In-season strength maintenance training increases well-	Investigate the effect of strength maintenance training on CSA, strength, and performance.	Cycling, Highly trained. T3. Male	30y (3)	MRI S.P.: Diet, physical activity,	*Not described*	*Not described*	Increased strength (23% (3)) and CSA (4.4% (0.6)) were maintained,

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
	trained cyclists' performance (60). 2010	Endurance + RT *versus* endurance only	(n=12) & female (n=1) Interventional		technical details on positioning			without change in BM, and with improvement in 40-min PPO (6% (2)), and W_{max} (8% (1)) during competition period.
	Differential correlations between anthropometry, training volume, and performance in male and female Ironman triathletes (52). 2010	Identify predictors of triathlon performance in nonprofessional athletes	Triathlon, Recreational T2. Male (n=27) & female (n=16) Prospective observation	30.3y (male) & 36.5y (female)	Skinfold[3] S.P.: Time of day, intratester reliability.	70,6mm (male) & 87mm (female) 13.7% (male) & 23,6% (female)[2]	41.0kg (4.7) (male) & 28.0kg (2.4) (female)[2]	47% of race time in females was explained by average weekly training volume (*negatively associated*). 55% of males' race time was explained by BF (%) (*positively associated*).
	Personal best marathon time and longest training run, not anthropometry, predict performance in recreational 24-hour ultrarunners (53). 2011	Identify predictors of ultramarathon race time performance	Ultrarunning, Recreational. T2. Male (n=63) Prospective observation	46.9y (10.3)	Skinfold[5] S.P.: Inter- and intratester reliability	89.9mm (31.1) 16.1% (4.1)[3]	*Not described*	Previous race performance and longest training session (*both negatively associated*), rather than anthropometric characteristics, were significant predictors of race success (total model explained

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
								47% of variance in race time).
	Personal best time, not anthropometry or training volume, is associated with total race time in a triple iron triathlon (58). 2011	Identify predictors for race time in triple triathlon finishers, comparing to non-finishers	Triathlon, Recreational. T2. Male (n=81) Prospective observation	39.0y (35.3-46.3)[$]	Skinfold[4] S.P.: Inter- and intratester reliability	72.3 mm (finishers) *versus* 80.8 mm (non-finishers) 13.7% (finishers)[3] *versus* 15.1% (non-finishers)[3]	40.3kg (finishers) *versus* 41.1kg (non-finishers)	BF (%) and SSK were positively associated with run-time and total race time in finishers. In the model explaining 87% of total race time, only previous personal best time was significant (*positively associated*).
	Similarities and differences in anthropometry and training between recreational male 100-km ultra-marathoners and marathoners (54). 2012	Investigate whether 100-km ultra-marathoners & marathoners were similar in anthropometry and training	Running, recreational. T2. Male (ultra-marathoners, n=166 & marathoners, n=126) Prospective observation	Ultra-marathoners 45.8 (9.5) & marathoners 42.8 (10.8)	Skinfold[3] S.P.: Inter- and intratester reliability Not ISAK.	86.6mm (32.4)[4] (ultra-marathoners) *versus* 87.4mm (27.2)[4] (marathoners) 16.2% (4.3)[3] *versus* 16.2% (3.7)[3]	38.9kg (3.9) (ultra-marathoners) *versus* 38.1kg (3.9) (marathoners)	No difference in anthropometry between groups. BM, BF (%), age (*all positively associated*) & weekly running km (*negatively associated*) predicted race time by 40% in ultra-marathoners. BF (%) (*positively associated*) and speed of running in training (*negatively*

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
								associated) predicted race time by 44% in marathoners.
	A Comparison of anthropometric and training characteristics among recreational male ironman triathletes and ultra-endurance cyclists (73). 2012	Investigate if race performance was related to anthropometric characteristics, training characteristics or both.	Triathlon & Ultra-endurance cycling, Recreational level. T2. Male triathletes (n=83) & Male ultra-cyclists (n=84) Prospective observation	Triathletes 41.5y (8.9) & ultra-cyclists 43.8y (7.5)	Skinfold[3] S.P.: Intra-tester reliability	15.7% (4.6) (triathletes) & 15.7% (4.3) (ultra-cyclists)	38.6kg (4.2) (triathletes) & 40.3kg (3.5) (ultra-cyclists)	46% of variance in race time in triathletes was explained by indices of FM (*positively associated*), while 44% of variance in split cycling time was explained by inducers of FM (*positively correlated*) and cycling speed in training (*negatively associated*). In cyclists 29% of variance in race time was explained in a model with only BF (%) significant.
	Effect of heavy strength training on muscle thickness,	Investigate the effect of supplemental heavy strength training on muscle thickness and	Nordic Combined, well-trained. T3.	19.5y (2.5)	Ultrasound S.P.:	*Not described*	*Not described*	Strength training increased muscle mass by 7.4% (2.7), with no

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
	strength, jump performance, and endurance performance in well-trained Nordic Combined athletes (62). 2012	determinants of performance in well-trained Nordic Combined athletes. Endurance + strength *versus* endurance only	Male (n= 17) Interventional		Time of day, rested.			change in BM. Upper- and lower body 1RM increased by 12% (2.0) and 23.0% (5.0), respectively. Vertical jump height increased by 8.8% (1.7). No change in VO_{2max} or TT in neither group.
	Comparison of training and anthropometric characteristic between recreational male half-marathoners and marathoners (56). 2013	Investigate relationship between anthropometrics and race time in half-marathoners and marathoners, respectively	Running, Recreational. T2. Male (n= 147 half-marathoners and 126 marathoners) Prospective observation	41.5y (10.5)	Skinfold[4] S.P.: Inter- and intratester reliability	99.9mm (35.6) (half-marathon) *versus* 88.3mm (26.2) (marathon) 17.5% (4.6) (half-marathon)[3] *versus* 16.3% (3.6) (marathon)[3]	39.1kg (3.1) (half-marathon) *versus* 38.3kg (3.3) (marathon)	Marathoners had lower BF than half-marathoners. BF (%) (*positively associated*) and running speed during training (*negatively associated*) predicted race time by 43-45% in both groups.
	Characteristics, changes, and influence of BC during a 4486 km transcontinental ultramarathon:	Investigate changes in BC measured by MRI and effect on performance	Ultramarathon, Recreational. T2. Male (n= 22)	49.1y (11.5)	MRI S.P.: Time of day, technical equipment standardisation	13.36 litre	37.32 litre	Baseline levels of VAT were negatively correlated with training volume and intensity over the year prior to

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
	results from the TransEurope FootRace mobile whole-body MRI-project (74). 2013		Prospective observation					the race. Change in VAT during race was the most sensible parameter to distinguish finishers from non-finishers.
	Strength training improves cycling performance, fractional utilization of VO2max and cycling economy in female cyclists (63). 2016	Investigate the effect of adding RT to cyclists' normal endurance training on cycling performance. Endurance + RT *versus* endurance only	Cycling, well trained. T2. Female (n=19) Interventional	33.2y (7.8)	MRI S.P.: Diet, physical activity, technical MRI procedure	*Not described*	*Not described*	RT increase 1RM in leg press (38.6 ± 19.0%) and thigh-muscle CSA (7.4 ± 5.3%) (BM did not change) and leads to improvements in cycling performance (6.4 ± 7.9% in MPO during 40 min all-out-test) and cycling economy (.3.5 ± 3.1% decrease in VO_2 at a PO of 150 W).
	Heavy strength training improves running and cycling performance following	Investigate the effects of adding RT to female duathletes' normal endurance training on both cycling and running performance.	Duathlon, well trained. T2. Female (n=19)	*Not given*	DXA S.P.: Diet, physical activity.	*Not described*	*Not described*	RT increased leg lean mass (3.1± 4.0%) and 1RM half-squat (45 ± 22%) , and improved 5 min all-out

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**[¤]	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
	prolonged submaximal work in well-trained female athletes (64). 2017	Endurance + RT *versus* endurance only	Interventional					performance immediately after prolonged submaximal work in both running distance (4.7 ± 6.0%) and MPO in cycling (7.0 ± 4.5%)
	Effect of two different intensity distribution training programmes on aerobic and BC variables in ultra-endurance runners (75). 2019	Investigate the effects of two different intensity distribution training programs on aerobic performance, strength and BC in ultra-endurance runners. Polarized (POL) *versus* Threshold (THR)	Ultra-endurance running. T2. Male (n=20) Interventional	38.7 (9.5)	DXA S.P.: Calibration of machine	POL: 18.4% (6.0) & THR: 14.9% (5.3)	POL: 56.6kg (6.8) & THR: 60.6kg (7.2)	THR reduced FM (-2.3kg) & BM (-1.6kg), hence BF (%) (-18.8%). POL reduced FM (-1.6kg), hence BF (%) (-11.2%). POL increased TTE (+2.4%) and RE at 10km/h (-5.4%) and 12km/h (-4.5%). Overall, no differences between groups.
	Anthropometric, physiological, and performance developments in cross-country skiers (57). 2021	Investigate whether changes in competitive performance (FIS-points) could be predicted by changes in laboratory-assessed qualities (incl. anthropometry) and training volumes	Cross Country skiing. Highly trained. T3. Male (n=16) & female (n=14) Longitudinal, prospective	20.5y (2.0)	DXA S.P.: Time of day, fasting.	*Not described* (Male: 9.7kg (1.5) & Female: 13.2kg (3.3)	Male: 63.0kg (5.8) & Female: 47.1kg (2.9)	FIS *distance* points were predicted by BM, FM, LBM, VO_{2peak} and speed in females, but no prediction of *sprint* points was significant. None of the

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								performance indicators could be predicted in males. Improvement in BC and aerobic capacity seems more beneficial for females than males.
Team sport	Fitness testing and career progression in AFL football (71). 2005	Investigate relationships between anthropometric & fitness tests, and subsequent career progression Drafted players *versus* not-drafted.	Australian Football, Talented players. T2. Male (n= 205 drafted; 78 not-drafted) Longitudinal, prospective cohort	18y	Skinfold[3] S.P.: ISAK level I trained.	56mm (13.0)	*Not described*	Fitness tests (20 min sprint time, running vertical jump, and agility- and shuttle run test), rather than anthropometry (not included in model), predict success of football career.
	Relationship between BC, leg strength, anaerobic power, and on-ice skating performance in division I men's hockey athletes (76). 2010	Investigate relationships between the off-ice laboratory testing of BC and leg strength and power, and on-ice skating speed.	Ice hockey, trained. T2. Male (n=21) Prospective observation	20.7y (1.6)	ADP S.P.: Diet, clothing, procedure according to manufacturer's instruction.	11.9% (4.6) (10.8kg; 4.7)	78.1kg (6.6)	19% of variance in fastest skating speed of short distances (54 m) were explained by %fatigue (*positively associated*) from Wingate test. Variance in average skating speed of short and longer

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								distances (54 - 89 m) were explained by BF (%) by 25%-29% (*positively associated*).
	Development of dribbling in talented youth soccer players aged 12-19 years: a longitudinal study (59). 2010	Identify predictors of dribbling and sprinting performance	Soccer, Talented youth players. T2. Male (n=267) Longitudinal, prospective cohort	12-19y	BIA S.P.: Not reported	7.43-9.59%	35.1kg (5.9) – 66.4kg (5.6)	LBM (×0.01) had a small effect on shuttle dribbling time; but age (×0.10) and training hours (×0.02) had stronger impact (*all negatively associated*)
	Increases in intracellular water explain strength and power improvement over a season (77). 2014	Investigate effect of changes in BC over a season on performance (leg strength and jump performance)	Team ball sports, Top national level. T3. Male (n=40) & female (n=23) Longitudinal, prospective cohort	20.0y (5.2)	DXA (and deuterium and bromide dilution) S.P.: Hydration status	15,6% (4.0) (male) & 25,9% (4.9) (female)	69.8kg (8.3) (male) & 47.4kg (6.5) (female)	Performance, FFM, TBW and ECW significantly increased, and %FM decreased. ICW was unchanged and was identified as the only predictor of performance (*positively associated*).
	The relationship between physical characteristic and match	Investigate whether anthropometric and physical abilities explained variance in match collision	Rugby, Elite union. T4. Female	25.0y (4.0)	Skinfold[4] S.P.:	*Not described*	*Not described*	Physical characteristics explain ~19% - 54% of the

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	collision performance among elite international female rugby union players (78). 2022	performance among rugby union players	(n=51) Longitudinal, prospective cohort		Time of day, fasted, ISAK level III trained.			variance in performance. High BM and BF (%) had positive influence by coefficients of 0.09 – 0.16, while power and strength coefficients were 0.08 – 0.25.
Combat / weight sport	Preparation of former heavyweight oarsmen to compete as lightweight rowers over 16 weeks: three case studies (66). 2006	Evaluate health and performance effects of BM-reduction in 3 lean athletes switching to lightweight category	Rowing, National level. T3. Male (n=3) Interventional	18-23y	Skinfold[4] S.P.: ISAK level III trained, intratester reliability.	39.7-81.3mm ~5.0-9.0kg£	~37.0-39.5kg£	While small loss of BM (2kg) was accommodated without loss of performance, athlete with largest loss of BM (8 kg, -0.84kg/wk)) showed absolute performance decrement (+6sec 2000m row).
	Combination of gradual and rapid weight loss: effects on physical performance and psychological state of elite	Investigate the effects of a gradual and rapid BM loss on the physical performance and psychological state of elite judo athletes. Weight loss *versus* control	Judo, national/international level. T3/T4. Male (n=10) & Female (n=10) Interventional	17.0y (1.0)	Skinfold[1] S.P.: *Not described*	11.8% (2.8) (male-weight loss) & 22.5% (7.5) (female-weight loss) *versus* 13.7% (5.4) (male-control) &	*Not described*	Weight-loss group lost 3.9% BM and 10% BF (%) in 4 weeks, both significantly more than control. Weight-loss impaired long-duration

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	judo athletes (69). 2009					23.6% (6.6) (female-control)		performance (>30 sec) by 4.5%, while tension and confusion increased, and vigour decreased.
	Long-term effect of weight loss on BC and performance in elite athletes (67). 2011	Investigate effect of rate of BM- reduction on long-term changes in BC and performance. Slow-rate (-0.7% of BM/wk) *versus* fast-rate (-1.4% of BM/wk).	Mixed sports, Elite level. T4. Male (n=9) & female (n=14) Interventional	22.5y (3.7)	DXA S.P: Fasting, time of day, calibration, intratester reliability.	16.5% (6.7) (male) & 29.0% (6.0) (female)	63.9kg (8.9) (male) & 45.6kg (4.5) (female)	Similar total loss of BM (-5.8% of BM) in both groups. Slow-rate BM-loss resulted in higher loss of FM (31% versus 23%) and a slight increase in LBM (+2.0%) compared to no change in LBM in fast-rate BM-loss. No difference between groups at 12 month follow up (both regained BM). Overall: LBM and performance well preserved during BM-reduction.
	The Psychological and Physiological	Investigate the effects of LEA on health and performance indices associated with the	Taekwondo, highly trained. T4.	19y	DXA S.P.:	16.7% (11.4kg)	54.5kg	8-week BW loss resulted in -9.8kg BM and -4.9kg FM. Only last

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	Consequences of Low Energy Availability in a Male Combat Sport Athlete (68). 2021	MAT and RED-S models.	Male (n=1) Interventional		Following published best practice protocol (79).			week with large energy deficit resulted in health markers impairment. Performance was preserved, athlete won BUC.
Speed / Strength sport	Longitudinal development of young talented speed skaters: physiological and anthropometric aspects (72). 1985	Identify the performance-determining factors for a successful speed skating career. Successful skaters compared to unsuccessful skaters.	Speed skating, national junior level. T2/T3. Female (n=12) & male (n=12) Longitudinal prospective cohort	16-17y	Skinfold[1] S.P.: Not reported	Female: 20.4% (3.6) (successful) *versus* 22.0% (1.5) (unsuccessful) Male: 10.1% (1.0) (successful) *versus* 9.9% (1.4) (unsuccessful)	Female: 48.7kg (2.6) (successful) *versus* 45.2kg (4.9) (unsuccessful) Male: 70.1kg (5.6) (successful) *versus* 66.2kg (6.5) (unsuccessful)	BC did not differ between successful or unsuccessful skaters. Success was characterised by high PO.
	BC and power performance improved after weight reduction in male athletes without hampering hormonal balance (70). 2015	Investigate the effects of 4-week BW reduction with high protein and reduced carbohydrate intake on BC, performance, hormones, and acid-base balance.	Track and field jump and sprint. T3/T4. Male (n=15) High energy restriction (-750 kcal/d) *versus* low energy restriction (-350 kcal/d) Interventional	20-35y	DXA S.P.: Not reported	High energy restr: 8.5% (2.3) & low energy restr: 10.6% (4.5)	High energy restr: 64.4kg (5.6) & low energy restr: 67.9kg (4.2)	Only high energy restriction achieved BM (-2.2 ± 1.0 kg) and FM reduction (-1.7 ± 1.6 kg), and performance improvement in countermovement jump (+2.6 ± 2.5 cm) and in 20m sprint (+0.04 ± 0.04 sec), but no

Sport taxonomy (50)	Study & year	Aim	Population, Sex & Design	Age	BC assessment method, & standardisation¤	Baseline BF (%) or SSK	Baseline MM	Outcome
								difference between groups. No changes in hormones. While BF (%) correlated negatively with jump performance, persons with baseline BF <10% were more likely to lose FFM and to have less improvement in performance.
Middle distance / Power sport	Anthropometric and metabolic determinants of 6,000-m rowing ergometer performance in international competitive rowers (80). 2009	Investigate the anthropometric and metabolic determinants of performance of 6,000m rowing	Rowing, Elite. T4. Male (n=25) Prospective observation	22.2y (4.8)	Skinfold[5] S.P.: Following ISAK protocol.	13.2% (2.3)	79.6kg (4.4)	PO at VT and forced vital capacity were best at predicting performance (by 77%) in 6000m rowing. LBM (r = -0.77) and PO at VT (r = -0.74) werethe strongest single correlate of performance.

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
	Case Study: BC Periodization in an Olympic-Level Female Middle-Distance Runner Over a 9-Year Career (11). 2018	Describe results from a science-based approach for BC periodization throughout a 9-year international career.	Middle distance running. Elite level. T5. Female (n=1) Longitudinal observation.	27-35y	Skinfold[4] S.P.: ISAK level I trained, intratester reliability.	61.6mm (9.7) 12.9% (1.4) 6.2kg (0.8)	42.1kg (0.7)	SSK and BF (%) varied by 13.0% and 17.8%,and MM by 0.9%, between non-competition and competition phases, SSK decreased by years, and the variation correlated positively with race time.

Sport taxonomy (50)	**Study & year**	**Aim**	**Population, Sex & Design**	**Age**	**BC assessment method, & standardisation**¤	**Baseline BF (%) or SSK**	**Baseline MM**	**Outcome**
Racquet sport	Physiological changes with periodized resistance training in women tennis players (65). 2003	Investigate physiological and performance adaptations to periodised or non-periodised RT or control condition	Tennis, Collegiate level. T2. Female (n=30) Interventional	19.0y (1.0)	Skinfold[2] S.P: Diet, physical activity, & time of day	22.9% (3.9) (periodised) *versus* 23.7% (4.9) (non-periodised) *versus* 22.6% (5.7) (control)	46.5kg (4.9) (periodised) *versus* 46.1kg (4.0) (non-periodised) *versus* 44.6kg (3.3) (control)	Although both programs induced changes in BC (reduced BF (%); increased FFM), periodised RT achieved superior improvements in FFM (change by 3.3 ± 1.7 kg versus 1.6 ± 2.4 kg) & sport performance (increase in jump height by 50% versus 37%; and in ball velocities in three strokes by (mean value) ~29% versus ~16%).

***NOTE**: 1RM, one repetition maximum (muscle strength); BF (%), percent body fat; ADP, Air Displacement Plethysmography; BC, body composition; BF, body fat; BIA, bioelectrical impedance; BM, body mass; BMI, body mass index; BUC, British University Championships; ctrl, control participants; CSA, cross sectional area; DXA, dual Xray absorptiometry; FFM, fat free mass; FM, fat mass; %FM, percent fat mass; ECW, extracellular water; ICW, intracellular water; LBM, lean body mass; MAT, male athlete triad; MM, muscle mass (measured/reported as LBM, FFM or MM in different studies); MPO, mean power output; MRI, magnetic resonance imaging; PO, power output; POL, Polarized training; PPO, peak power output; RE, running economy; RT, resistance training; SBE_{100}, season's best equivalent for 100m sprint; SSK, sum of skinfolds; S.P., standardisation procedure (for anthropometric measurement); TBW, total body water; T1-T5, THR, Threshold training, Tier 1-5 performance level of athletes(49); TT, time trial; TTE, time to exhaustion; VAT, visceral adipose tissue; VT, ventilatory threshold; WL, weight loss; W_{max}, mean power output in Watts; y, year; [1]SSK 4 sites ;[2]SSK 3 sites; [3]SSK 7 sites;[4]SSK 8 sites; [5]SSK 6 sites; [6]SSK 9 sites; [£]captured from graphic illustration; [$]numbers are median (interquartile range); ¤standardisation includes one or more of the following: measurement performed according to best practice/guidelines, calibration of equipment, training of measurer, evaluation of hydration status, standardisation of assessment protocol (i.e., time of day, diet and physical activity).*