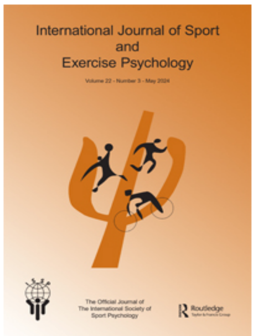

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The behavioural regulation in exercise questionnaire (BREQ): psychometric properties and associations with physical activity outcomes in a Norwegian sample of physically active adults

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ABSTRACT

We investigate the factor structure and psychometric properties of different versions of the Behavioural Regulation in Exercise Questionnaire (BREQ), which measures exercise motivation, and explore the association with physical activity (PA) outcomes, in a Norwegian sample of physically active adults. The sample consisted of $N = 1198$, 68.9% men, mean age 49.1 ($SD = 11.4$) using a cross-sectional design. We analysed several BREQ versions with confirmatory factor analysis to retain the one with the best model fit: The 15-item BREQ, 19-item BREQ-2, 19-item BREQ with integrated regulation, 18-item BREQ-3, and 24-item BREQ-3. An 18-item BREQ-2 with five factors (external, introjected, identified, and intrinsic regulation, and amotivation) showed excellent model fit ($\chi^2 = 493.848$; df = 125; RMSEA = .050; 90% CI [0.045-0.054]; CFI = .975; TLI = .969; SRMR = .041), with the item “I get restless if I don’t exercise regularly” removed. Configural, metric, scalar, and strict measurement invariance was supported. Intrinsic motivation was associated with the PA index (PA-I), PA frequency, duration, and intensity, and estimated cardiorespiratory fitness (eCRF). Identified regulation was associated with PA-I, PA frequency and eCRF, and introjected regulation with PA-I and intensity. External regulation was negatively related to PA frequency and eCRF, while amotivation was unrelated to all outcomes. The results support the factorial validity of the 18-item BREQ-2. The poor model fit found for other BREQ versions warrants additional studies to investigate the psychometric properties in physically active adult samples. Autonomous motivation factors were most important for PA outcomes.

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Background

The World Health Organization (WHO) recommends that adults should engage in moderate physical activity (PA) for 150 min pr week, or 75 min weekly of vigorous activity (World Health Organization, 2020). Adherence to the WHO recommendations reduces risk of lifestyle illnesses like coronary disease, high blood pressure, diabetes, cancer, and dementia (Bull et al., 2020; Zotcheva et al., 2018). PA has a positive effect on mental health and is effective both in the prevention and treatment of depression (Ashdown-Franks et al., 2020; Kvam et al., 2016; Schuch et al., 2018) and anxiety (Ashdown-Franks et al., 2020; Rebar et al., 2015). Some figures show that as few as one third of the adult population meet the WHO guidelines (Hallal et al., 2012; Jiménez-Pavón et al., 2012; Loyen et al., 2016; Marques et al., 2015), which means that a large proportion of the adult population may be at risk of physical or mental problems due to inactivity.

The self-determination theory (SDT) (Deci & Ryan, 1985; Ryan & Deci, 2017) is a conceptual framework for understanding an individual's motivation. Within SDT, the mini theory of Organismic Integration Theory (Ryan & Deci, 2002) describes motivation along a continuum, depending on how well motivation is integrated in the perception of self. The continuum contains the three motivation types amotivation, intrinsic motivation and extrinsic motivation (Deci & Ryan, 2000). Amotivation refers to lack of motivation for a given behaviour. Intrinsic motivation refers to self-determined behaviour that is conducted solely because of the enjoyment and satisfaction of the activity itself, for example to exercise because of feelings of mastery and enjoyment. Extrinsic motivation refers to activities conducted to achieve something external to the activity itself, such as exercising to change body appearance. Extrinsic motivation can be divided into external regulation, introjected regulation, identified regulation and integrated regulation. External regulation refers to PA conducted due to external pressure, to achieve rewards or avoid punishment. Introjected regulation relates to exercise motivated by internal pressures, coerced by internal standards and contingent self-esteem. This would include exercising to avoid feelings of shame or guilt, or to achieve a sense of pride. Identified regulation pertains to value in the activity itself, accepting exercise as something personally important and valuable. Integrated regulation is the most autonomous form of extrinsic motivation and is about integrating the values of exercise into a coherent sense of self relates to behaviour that the individual experiences as part of themselves. Of the extrinsic regulation types, external- and introjected regulation are considered controlled motivation and identified- and integrated regulation are considered autonomous motivation, together with intrinsic motivation. There is extensive research investigating the relationship between self-determined motivation and PA in different contexts, consistently showing that self-determined motivation, i.e., identified regulation, integrated regulation and intrinsic motivation, predict both short-term adoption and long-term exercise adherence (Teixeira et al., 2012).

The Behavioural Regulation in Exercise Questionnaire (15-item BREQ) (Mullan et al., 1997) was developed based on the SDT to measure external regulation, introjected regulation, identified regulation and intrinsic motivation. This scale was later modified by Markland and Tobin (2004) who included a subscale that assesses amotivation towards exercise behaviour, which had been eliminated from the original BREQ. This 19-item BREQ-2 showed a five-factor structure. Wilson et al. (2006) revised the original BREQ

(Mullan et al., 1997) by adding four items to measure integrated regulation in exercise behaviour; the 19-item BREQ.

Cid et al. (2018) developed the Portuguese 24-item BREQ-3, by combining the 19-item BREQ-2 by Markland and Tobin (2004) with the four integrated regulation items by Wilson et al. (2006) and adding one item measuring introjected regulation to overcome limitations of the BREQ-2 (Cid et al., 2012). Confirmatory factor analysis (CFA) indicated improved model fit by excluding one item per factor, hence they retained an 18-item BREQ-3 with six factors. However, the proposed 24-item and six-factor BREQ-3 scale was tested by Rodrigues et al. (2020), who investigated several models specifying different numbers of factors with both exploratory structural equation modelling, CFA and bifactor-models. The authors favoured the six-factor 24-item BREQ-3.

There is extensive evidence supporting the predictive ability of BREQ, in particular the 19-item BREQ-2, for physical activity outcomes. Intrinsic motivation is associated with better aerobic fitness and increased physical activity levels, and introjected regulation is associated with body fat composition (Mahony et al., 2019; Sibley et al., 2013). The BREQ-2 also predicts VO_{2peak} in elderly cardiac patients (Mikkelsen et al., 2022) and long-term adherence to physical activity (Rosa et al., 2015). Integrated regulation is associated with both PA intention and behaviour, including duration, frequency and intensity of the activity (Duncan et al., 2010; Miquelon et al., 2017). Certain gender differences have been identified with introjected regulation predicting PA intensity for women, but not for men (Duncan et al., 2010). In a study applying the BREQ-3, integrated regulation was the most important motivation-regulation style for physical activity frequency in adults (Box et al., 2019).

Physical activity may be defined as movements that require use of energy, and cardiorespiratory fitness (CRF) is the ability of the cardiac circulatory, respiratory and muscular systems to provide a satisfactory level of oxygen for physical exercise (Ross et al., 2016). PA increases the level of CRF, which in turn is associated with positive health outcomes. CRF is associated with reduced risk of depression, cardiovascular disease and mortality (Kodama et al., 2009; Schuch et al., 2016). CRF may be estimated (i.e., eCRF) through non-exercise algorithms with a sufficient degree of accuracy compared to directly measured peak oxygen uptake (Nes et al., 2011, 2014). Although there are several studies on the association between BREQ and physical activity and some research on the association with directly measured VO_{2peak}, the possible relation between BREQ and eCRF has not been investigated previously.

Given the previous inconsistent findings regarding different versions of the BREQ, there is a need to investigate the factor structure and psychometric properties in a Norwegian context. In the current study we evaluate the four-factor 15-item BREQ (Mullan et al., 1997), the five-factor 19-item BREQ-2 (Markland & Tobin, 2004), the five-factor 19-item BREQ (Wilson et al., 2006), the six-factor 18-item BREQ-3 (Cid et al., 2018) and the six-factor 24-item BREQ-3 (Rodrigues et al., 2020) in a Norwegian sample of highly physically active adults, to evaluate the scales' usefulness in this population. Further, we will investigate the associations between the best fitting BREQ version and relevant physical activity outcomes, including PA frequency, duration and intensity, as well as eCRF. No a priori hypothesis was formulated to test the factor structure of the BREQ scale as this study examines various competing versions of the BREQ scale. However, we hypothesise that the best fitting BREQ scale will significantly predict physical activity outcomes.

Methods

Participants and procedure

The present study reports cross-sectional data from an ongoing longitudinal study of members of a Norwegian organisation for endurance sports. Invitations were sent by e-mail to all members ($N = 6{,}766$, male = 75%). Information about the study was presented and participants consented to participation before being forwarded to the online survey. All data handling was conducted without protected health information identifiers. Data was collected between June 3, 2020, and June 15, 2020.

The sample consisted of 1198 participants (68.9% men, mean age = 49.09 [$SD = 11.39$]) who were included in data analysis. One-hundred and twenty-four (10.4%) reported to have a limiting long-term physical or mental illness. Regarding level of education, 190 (15.9%) had finished primary school, 321 (26.8%) reported less than 4 years of college or university studies, and 687 (57.3%) reported 4 years or more at college or university. Nine-hundred and sixty-seven (80.7%) reported to live with a partner, 146 (12.2%) lived alone, and 82 (6.8%) lived with children.

Physical activity

Weekly PA level was recorded with questions about frequency (How often do you exercise: "never, less than once a week," "once a week," "two to three times a week," and "four or more times a week"), intensity (How hard do you exercise? "no sweat or heavy breath," "heavy breath and sweat," and "push myself to exhaustion") and duration ("<15 min," "between 15 and 30 min," "between 30 and 60 min," and ">60 min"). The PA questions have previously been validated by comparison with objective PA measures and the International Physical Activity Questionnaire (Kurtze et al., 2008). Item responses were weighted according to a validated procedure (Nes et al., 2011), and the sum score of the weighted responses equals the Physical Activity Index (PA-I).

Estimated cardiorespiratory fitness (eCRF)

eCRF was estimated through a non-exercise prediction model validated previously (Nes et al., 2011, 2014) with the following logarithm: Women: 70.77 − (0.244 AGE) − (0.749 Body Mass Index; BMI) − (0.107 Resting Heart Rate; RHR) + (0.213 PA-I). Men: 92.05 − (0.327 AGE) − (0.933 BMI) − (0.167 RHR) + (0.257 PA-I).

Measures

The Behavioural Regulation in Exercise Questionnaire (24-item BREQ-3) (Cid et al., 2018; Rodrigues et al., 2020) was administered to measure motivation for exercise. Items were scored on a 5-point Likert scale from 0 ("completely disagree") to 4 ("completely agree"). The BREQ items have been translated to Norwegian previously (Bangor University, 2023; Skjelten, 2016).

Statistical analyses

SPSS 24.0 was used for descriptive statistics, correlational and linear regression analyses. All other analyses were performed in Mplus version 8.7 (Muthén & Muthén, 1998–2021) using full-information maximum likelihood (FIML) which is considered a state of the art approach for handling missing values as it makes use of all available data (Schafer & Graham, 2002), therefore missing values were not replaced. Mardia's skewness and kurtosis tests of normality were calculated to assess the underlying assumption of multivariate normality. In our first stage of analyses, we tested the fit of several competing BREQ factor models to select the best fitting model through Confirmatory Factor Analytic (CFA) framework, by allowing items to load on a priori factors without any cross-loadings. Existing models tested were in correspondence to our 24-item BREQ-3 data (see Table 1), including the four-factor 15-item BREQ (Mullan et al., 1997), five-factor 19-item BREQ-2 (Markland & Tobin, 2004), five-factor 19-item BREQ (Wilson et al., 2006), six-factor 18-item BREQ-3 (Cid et al., 2018) and finally, the six-factor 24-item BREQ-3 (Rodrigues et al., 2020). Based on the results, we select the model with the best model to data correspondence.

Having established an adequate model fit, we proceeded to test measurement invariance across women and men. Examination of measurement invariance is one of the best methods for investigating whether an instrument measures the intended latent construct equivalently across groups (F. F. Chen, 2007). Measurement invariance analysis can pinpoint any sources of differences across a hierarchy of levels that range from metric or weak to strict in terms of invariance. An unconstrained configural invariance was tested first, which also represented the baseline model for the subsequent and more restrictive models. Metric invariance was tested by constraining all factor loadings as equal across women and men. Next, we constrained the intercepts to be equal across women and men to test scalar invariance. Strict invariance was tested by constraining all item residual variances as equal across groups. Although model fit indices may point to acceptable fit (MacCallum et al., 1996), adequate to excellent model fit was evaluated with the following indices: Standardized Root Mean Square Residual (SRMR) and Root Mean Square Error of Approximation (RMSEA) values less than .08 and values equal to or less than .06 (upper 90% CI close to or $< .06$), respectively (Browne & Cudeck, 1993); a Comparative Fit Index (CFI) and a Tucker-Lewis Index (TLI) greater than .95 (Hu & Bentler, 1999). Nested models in the measurement invariance testing were compared using change (Δ) in absolute and incremental fit indices. A change of $\geq -.010$ in CFI and $\geq .015$ in RMSEA or a change of $\geq .030$ in SRMR were used as indicating non-invariance when testing metric invariance. For testing scalar and strict invariance, we used the same changes in CFI and RMSEA, supplemented by a change of $\geq .010$ in SRMR as indicating non-invariance (F. F. J. S. e. m. Chen, 2007; Cheung & Rensvold, 2002).

Table 1. Model fit statistics in the CFA analyses ($N = 1198$).

Model	Type	χ^2	*df*	RMSEA	CFI	TLI	SRMR
CFA							
M1.1	BREQ (Mullan et al., 1997)	584.567	84	.071 [0.065, 0.076]	.937	.921	.056
M1.2	BREQ–2 (Markland & Tobin, 2004)	738.024	142	.059 [0.055, 0.063]	.960	.952	.052
M1.2*	BREQ–2 (Markland & Tobin, 2004)	493.848	125	.050 [0.045, 0.054]	.975	.969	.041
M1.3	BREQ + Integrated regulation (Wilson et al., 2006)	993.758	142	.071 [0.067, 0.075]	.916	.899	.062
M1.4	BREQ–3 (Cid et al., 2018)	784.854	120	.068 [0.064, 0.073]	.942	.926	.058
M1.5	BREQ–3 (Rodrigues, 2020)	1480.006	237	.066 [0.063, 0.069]	.930	.919	.072

Note: *The final model eliminated "I get restless if I don't exercise regularly".

To evaluate construct validity, the Average Variance Extracted (AVE) for each construct was evaluated against its correlation with the other constructs (Cheung & Wang, 2017; Fornell & Larcker, 1981; Hair, 2009). Convergent validity was confirmed when the AVE was larger than the construct's correlation with other constructs and minimally explained an average of 50% (i.e., ≥0.50 for AVE), and composite reliability (factor rho coefficient, ρ) was higher than 0.6 (Fornell & Larcker, 1981). Discriminant validity was confirmed when the square root of the AVE value is larger than correlation between two constructs (Fornell & Larcker, 1981; Hair, 2009). Finally, we performed multiple regression analyses controlling for demographic variables in step 1, education, and workout with others in step 2, and BREQ factors in step 3. The various physical activity outcome variables were tested in separate regression models.

Results

Preliminary cleaning and screening

The data was non-normally distributed (Women: Mardia's multivariate skewness, $M_S = 48370.504$, $p < .001$; Mardia's multivariate kurtosis, $M_K = 213.961$, $p < .001$; Men: $M_S = 67191.891$, $p < .001$; $M_K = 272.026$, $p < .001$), therefore cases that were considered substantial multivariate outliers were removed ($n = 105$) based on Mahalanobis distance because they would disproportionately influence results. The final sample consisted of 1198 participants (68.9% men) with a mean age of 49.09 ($SD = 11.39$).

Mean differences across gender

Significant gender differences emerged in only *identified regulation*, indicating that women reported slightly higher levels than men (Mean women: $M_w = 11.35$ vs Mean men: $M_m = 11.22$, $t(1196) = 1.95$, $p < .05$; Cohen's $d = .12$). Following were the mean scores for the rest of the factors: *External regulation* ($M_w = 0.51$ vs $M_m = 0.57$, $t(1196) = -0.83$, $p = .20$), *introjected regulation* ($M_w = 5.65$ vs $M_m = 5.41$, $t(653,37) = 1.39$, $p = .08$), *intrinsic regulation* ($M_w = 14.45$ vs $M_m = 14.39$, $t(1196) = 0.52$, $p = .30$), and *amotivation* ($M_w = 0.04$ vs $M_m = 0.06$, $t(916,49) = -1.15$, $p = .12$).

Psychometric properties of the BREQ-2

Inspection of the different competing models in Table 1 revealed that the 19-item BREQ-2 (Markland & Tobin, 2004) with the amotivation factor had the best model correspondence to the data while the 19-item BREQ with integrated regulation (Wilson et al., 2006) had the worst fit. We further systematically inspected localised areas of ill fit including the standardised pattern coefficients (λ), residual variances (δ) and explained variances (R^2) across all the factor models to determine the substantive fit of the final model. Based on our inspections, Item 19 "I get restless if I don't exercise regularly", had the smallest standardised pattern coefficient ($\lambda = .43$), the smallest explained variance ($R^2 = .19$) and the largest residual variance ($\delta = .81$) in the final model and showed similar features in the other models. Since this item was found to cause localised strain in all the models, it was eliminated from the final model, leading to an improved model fit to the data ($\chi^2 = 493.848$, *df*

= 125, $p < .001$; SRMR = .041; RMSEA = .050 [90% CI = 0.045, 0.077]; CFI = .975; TLI = .969). All model fit indices are presented in Table 1, with the retained factor model and standardised pattern coefficients displayed in Table 2.

Measurement invariance of BREQ-2 across gender

The retained 18-item, five-factor BREQ-2 (M1.2* in Table 1) adequately replicated across both women (M1a in Table 3) and men (M1b in Table 3) and was slightly better in the

Table 2. Confirmatory factor analysis (CFA) model with standardised factor loadings and factor correlations ($N = 1198$).

	CFA Solution				
Item	External regulation	Introjected regulation	Identified regulation	Intrinsic regulation	Amotivation
External regulation					
Because other people say I should	.78				
Because friends/family/ partners say I should	.79				
Because others will not be pleased with me	.64				
I feel under pressure from others	.81				
Introjected regulation					
I feel guilty when I don't exercise		.59			
I feel ashamed when I miss exercise		.72			
I feel a failure when I haven't exercised		.68			
Identified regulation					
I value the benefits of exercise			.86		
It's important to me to exercise regularly			.79		
It's important to make an effort to exercise			.55		
Intrinsic motivation					
I exercise because it's fun				.75	
I enjoy my exercise sessions				.82	
I find exercise a pleasurable activity				.78	
I get pleasure/satisfaction from exercise				.76	
Amotivation					
I don't see why I should exercise					.89
I can't see why I should bother exercising					.93
I don't see the point in exercising					.97
I think exercising is a waste of time					.89
Factor correlations					
Correlations with Introjected regulation	.29***				
Correlations with Identified regulation	−.70***	−.13**			
Correlations with Intrinsic regulation	−.68***	−.29***	.79***		
Correlations with Amotivation	.79***	.24***	−.86***	−.70***	

Table 3. Measurement invariance analysis ($N_{women} = 373$; $N_{men} = 825$).

Model	Type of test	Compared with	χ^2	*df*	RMSEA	CFI	TLI	SRMR	*Δdf*	*ΔCFI*	*ΔRMSEA*	*ΔSRMR*
M1a	Women		393.558	125	.076 [0.068, 0.084]	.959	.950	.051				
M1b	Men		338.935	125	.046 [0.040, 0.051]	.972	.966	.042				
M2	Configural		732.493	250	.057 [0.052, 0.062]	.966	.959	.045				
M3	Metric (λ)	M2	778.526	263	.057 [0.053, 0.062]	.964	.958	.047	13	−.002	.000	.002
M4	Scalar (λ, ν)	M3	828.036	276	.058 [0.053, 0.062]	.961	.957	.048	13	−.003	.001	.001
M5	Strict (λ, ν, δ)	M4	1069.957	294	.066 [0.062, 0.071]	.946	.943	.061	18	−.015	.008	.013

men sample. With this reasonable replication, configural invariance (M2) was supported as the equivalent five-factor model in both samples with identical factor-item patterns had acceptable fit, thus, providing support for structural stability of 18-item BREQ-2.

Metric invariance

The baseline unconstrained configural invariance model (M2) was compared to the next level of invariance model constraining the factor loadings equally across women and men, thus testing the important assumption of metric invariance (M3). The worsening in fit was not substantial as it did not reach the threshold for non-invariance (ΔCFI = −.002; ΔRMSEA = −.000; ΔSRMR = .002), hence, both models were equivalent.

Scalar invariance

The fit of the model constraining factor loadings and item intercepts equal (M4) was not substantially worse than the model allowing different item intercepts across women and men (M3), even though the CFI, TLI and SRMR all slightly degraded, but not the RMSEA. The worsening in fit was trivial (ΔCFI = −.003; ΔRMSEA = .001; ΔSRMR = .001). Support for scalar invariance was thus achieved.

Strict invariance

Constraining factor loadings, intercepts, and error variances equal (M5) did not result in a substantial worsening of fit (ΔCFI = −.015; ΔRMSEA = .008; ΔSRMR = .013) compared to model M4, which freely estimated all error variances; hence, full support of strict invariance was evident. The worsening in CFI and SRMR was marginal to the threshold (−.015) and (.010), respectively. However, the RMSEA which penalises for model misspecification in relation to model complexity and sample size was greatly below the threshold (.015) for non-invariance, hence our decision to retain the strict invariance model.

Convergent and discriminant validity of the BREQ-2

The composite reliability (factor rho coefficient, ρ) values were all higher than .60 including, external regulation (ρ = .84), introjected regulation (ρ = .70), identified regulation (ρ = .78), intrinsic regulation (ρ = .86), and amotivation (ρ = .96). The AVE values for Introjected (AVE = .33) and identified (AVE = .42) regulation were below the cut-off (0.50). The AVE for external (AVE = .57), intrinsic (AVE = .60) and amotivation (AVE = .85) were above the cut-off thus, supporting convergent validity. The square root of the AVE values indicated an issue concerning the correlation between external regulation and amotivation, which could mean discriminant validity was not supported between these two factors, and it was the same for the corelation between identified and intrinsic regulation.

Incremental validity of BREQ-2 through multiple regressions of physical activity outcomes

Multiple regression analyses investigated the association between BREQ subscales and physical activity outcomes (Table 4). We report the squared semi-partial correlations for

Table 4. Multiple regression of the association between BREQ-2 and physical activity outcomes ($N = 1198$).

Steps		Outcome																			
		PA index				PA frequency				PA duration				PA intensity				eCRF			
		ΔF	ΔR^2	β	t	ΔF	ΔR^2	β	t	ΔF	ΔR^2	β	t	ΔF	ΔR^2	β	t	ΔF	ΔR^2	β	t
1																					
	Age			.01	.48			−.06	−2.05*			.03	.94			.03	1.08			−.61	−43.15***
	Gender			−.05	−1.80			.00	.02			−.09	−3.07**			−.06	−1.84			−.75	−53.03***
	Illness			.02	.73			.01	.21			.04	1.46			.02	.71			−.02	−1.06
		.56	.00			2.46	.01			2.54	.01			.91	.00			1318.17	.78		
2																					
	Education <4 years			−.00	−.06			−.05	−1.24			−.03	−.83			.01	.32			.05	2.57*
	Education ≥4 years			.03	.72			−.02	−.42			−.01	−.31			.04	.89			.09	4.72***
	Workout with others			.04	1.35			.05	1.64			.09	2.91**			.03	.92			.02	1.46
		1.46	.00			2.73	.01			4.77	.01			.70	.00			8.00	.01		
3																					
	External			−.04	−1.48			−.08	−2.67**			−.05	−1.82			−.02	−.75			−.04	−2.45*
	Introjected			.08	2.56*			−.02	−.74			−.02	−.65			.09	2.88**			−.00	−.22
	Identified			.11	3.47***			.20	6.39***			.08	2.67*			.06	1.77			.04	2.43
	Intrinsic			.15	4.56***			.13	4.16***			.15	4.79***			.11	3.52***			.07	4.43***
	Amotivation			.03	0.89			−.05	−1.60			.01	.21			.04	1.35			.01	.41
		12.63	.05			22.09	.09			11.04	.05			6.66	.03			10.18	.01		

Note: *$p < .05$; **$p < .01$; ***$p < .001$. Education <4 years = University/college < 4 years; Education ≥4 years = University/college ≥ 4 years; PA: Physical activity; eCRF: Estimated Cardiorespiratory Fitness.

significant predictors as an indicator of the change in unique variance explained (ΔR^2) by the predictor. The analyses were controlled for age, gender, long-standing limiting illness of physical or psychological nature, education, and how often the participants reported to workout with others. For physical activity index as outcome, introjected regulation ($\beta = .08$, $p < .05$; $\Delta R^2 = .07$), identified regulation ($\beta = .11$, $p < .001$; $\Delta R^2 = .10$), and intrinsic motivation ($\beta = .15$, $p < .001$; $\Delta R^2 = .13$) were significant predictors. For physical activity frequency as outcome, external regulation ($\beta = -.08$, $p < .01$; $\Delta R^2 = .08$), identified regulation ($\beta = .20$, $p < .001$; $\Delta R^2 = .18$), and intrinsic motivation ($\beta = .13$, $p < .001$; $\Delta R^2 = .12$) were significant predictors. For physical activity duration, identified regulation ($\beta = .08$, $p < .01$; $\Delta R^2 = .08$) and intrinsic motivation ($\beta = .15$, $p < .001$; $\Delta R^2 = 0.14$) were significant predictors. For physical intensity as outcome, introjected regulation ($\beta = .09$, $p < .01$; $\Delta R^2 = .08$) and intrinsic motivation ($\beta = .11$, $p < .001$; $\Delta R^2 = .10$) were significant predictors. For estimated eCRF as outcome, external regulation ($\beta = -.04$, $p < .05$; $\Delta R^2 = -.03$), identified regulation ($\beta = .04$, $p < .05$; $\Delta R^2 = .03$) and intrinsic motivation ($\beta = .07$, $p < .001$; $\Delta R^2 = .06$) were significant predictors.

Discussion

In the present study we investigated the factor structure and psychometric properties of different competing models of the BREQ in a Norwegian sample of physically active adults. Support was found for an 18-item BREQ-2 as the best fitting model for assessing behavioural motivation in exercise contexts. In addition, we explored if the supported model was associated with outcomes related to physical activity. As hypothesised, the results showed significant associations between the 18-item BREQ-2 with the PA-index, frequency, intensity, and duration as well as with eCRF.

The participants completed the 24-item BREQ-3, which we had intended to use for further analysis if sound psychometric properties were established. We did not achieve satisfactory model fit for a six-factor solution of the 24-item BREQ-3, which contrasts previous research (Rodrigues et al., 2020). It should be noted that Cid et al. (2018) also found a poor model fit for the 24-item six-factor BREQ-3, which led the authors to remove one item per factor and retain an 18-item scale with six factors, that demonstrated excellent model fit. However, when we tested the revised scale proposed by Cid et al. (2018), we found that although some of the fit indices improved, the model still did not obtain excellent model fit.

The use of the 24-item BREQ-3 allowed us to test multiple versions of the BREQ to identify the scale with the best model fit. In addition to testing the six-factor 18-item BREQ-3 (Cid et al., 2018) and the six-factor 24-item BREQ-3 (Rodrigues et al., 2020) previously mentioned, we also evaluated the factor structure of the four-factor 15-item BREQ (Mullan et al., 1997), the five-factor 19-item BREQ-2 (Markland & Tobin, 2004) and the five-factor 19-item BREQ with integrated regulation (Wilson et al., 2006).

By use of CFA, the results showed that of the abovementioned scales, the 19-item BREQ (Wilson et al., 2006) was associated with the worst model fit and the 19-item BREQ-2 (Markland & Tobin, 2004) showed the best model fit. However, inspection of modification indices revealed that the BREQ-2 item 19, "I get restless if I don't exercise regularly", from the identified regulation subscale was problematic. The item had smallest standardised factor loading ($\lambda = .43$), showed low explained variance ($R^2 = .19$) and was associated with the largest residual variance ($\delta = .81$). Upon inspection of the other models tested, this item had similar problematic features across the remaining models. We therefore decided to remove this item from the final model, which led to an excellent model fit.

Item 19 has also been identified as problematic in previous research. In the study by Markland and Tobin (2004) the same item was removed from the statistical analysis due to an error which was not specified. With this item omitted, the 18-item 5-factor model had good model fit. In the Portugese translation the same item had low loading on the identified regulation factor (Cid et al., 2012; Palmeira et al., 2007), and the study by Cid et al. (2012) also reported satisfactory model fit when this item was excluded. The author of the latter study suggested that the wording of item 19 may fit more closely with the subscale introjected regulation, which relates to activities one engages in to avoid internal feelings of guilt or anxiety. The identified regulation subscale on the other hand measures the motivation for activities that the person not necessarily enjoys, but still carries out, because the activity is personally important and valuable. By using exploratory factor analysis, Palmeira and Teixeira (2007, cited in Cid et al., 2012) reported evidence to support this argument, as they found that item 19 loaded on the introjected regulation factor. A Spanish version of the BREQ-2 also found poor abilities of the item 19, with a loading of less than $\lambda = .40$ on the idenfied regulation factor, and good model fit with the item excluded. Altogheter, these previous results corroborate those of our study which indicate that item 19 is associated with theoretical and methodological issues that questions the inclusion of this item.

In tests of measurement invariance, we found support for metric, scalar and strict invariance. These findings corroborate previous research which also have shown measurement invariance for the 18-item BREQ-2 across gender (Chung & Dong Liu, 2012; Vlachopoulos, 2012). For measurement invariance, metric invariance is the most important test because this measures equal factor loadings across groups. Strict invariance is more rarely supported in research, as the prerequisite for this is that item residuals variances are constrained to equality across groups, which in many cases is a too strict requirement. It is promising that the 18-item BREQ-2 achieved measurement invariance on all domains tested, which supports the scale as having satisfactory psychometric properties to measure behavioural motivation in exercise in both women and men.

In line with the measurement invariance demonstrated for gender, men and women in the sample reported equal levels of the BREQ subscales apart from identified regulation, for which women had a somewhat higher mean value than men. The approximately identical scores reported by men and women are in line with the meta-analysis of BREQ-2 by Guérin et al. (2012) who did not find gender differences in any of the BREQ subscales. However, studies with student populations have found women to be more motivated by extrinsic factors, and men reporting higher levels of intrinsic motivation (Lauderdale et al., 2015). Lower amotivation and higher identified and intrinsic regulation in men than women has also been reported in undergraduate students (Daley & Duda, 2006). It has been suggested that men place less value on appearances than women, which may contribute to explain the gender differences (Muth & Cash, 1997). The overall equal scores of men and women in our study may indicate that gender differences in the motivation factors are more pronounced in younger adults. Furthermore, the results from college-aged student populations may not be comparable to those found in our study, which included a majority of men with a mean age of 49.

In a series of multiple regression analyses we investigated if the BREQ subscales were associated with various physical activity outcomes. The results showed that intrinsic motivation was statistically significantly associated with all outcomes, i.e., the physical activity index, physical activity frequency, physical activity duration, physical intensity, and eCRF. These associations are in line with previous research that has found intrinsic motivation to be associated with improved aerobic fitness (Sibley et al., 2013), increased physical activity (Mahony et al., 2019) and directly measured VO_{2peak} (Videm et al., 2022; Wilson et al., 2003). Intrinsic motivation involves autonomous behavioural regulation to exercise where individuals are driven by enjoyment and satisfaction, and the inherent, self-rewarding nature of exercise, which can lead to greater persistence and intention to continue exercising, associated with improved physical activity and fitness.

Teixeira et al. (2012) reviewed the literature and found intrinsic motivation and identified regulation to be most important for PA. They concluded that although intrinsic motivation may be more important for long-term exercise maintenance, identified regulation was somewhat more consistently found to predict exercise in general. We found identified regulation to be associated with the PA index, PA frequency and eCRF, which is in line with previous studies (Teixeira et al., 2012; Videm et al., 2022). Interestingly, however, identified regulation was not associated with higher PA intensity and duration, as opposed to the intrinsic motivation. Identified regulation is related to activities that are perceived to be highly valued and important to the individual, whereas intrinsic motivation relates to activities that are experienced as pleasurable in themselves. Both intrinsic motivation and identified regulation are considered to express autonomous motivation and have a positive impact on PA. One interpretation may therefore be that those who are more intrinsically motivated experience intensive activities as inherently satisfying, but that for those with higher identified regulation the intensity and duration of activities are not as highly valued and significant. Thus, endorsing the goal values or importance of PA may not mean that one will enjoy intensive and prolonged physical activities, whereas individuals who find pleasure and enjoyment in exercising enjoy both the intensity and duration.

Introjected regulation was a significant predictor for the PA index and intensity, which corroborates the results reported by Duncan et al. (2010), who also found an association between introjected regulation and intensity. Taking a broader view, the relationship between introjected regulation and PA appears complicated, with some studies indicating a positive relationship with PA and other a negative relationship (Edmunds et al., 2006; Teixeira et al., 2012). Introjected regulation is considered to be controlled motivation and reflects a person's expectation for themselves. To accomplish these expectations may, on the positive side, lead to an improved sense of worth, reduced distress and anxiety, and a feeling of pride. However, introjected regulation also taps into negative feelings of shame and guilt, leading to possible negative effects when not accomplishing the expectations. The positive relationship between introjected regulation and the PA index and PA frequency in our study could be explained by our sample being relatively active adults recruited from organised sport. It is apparent that introjected regulation was of importance for only two of the outcomes, as compared to the identified regulation that was associated with three PA outcomes and intrinsic motivation subtype which was associated with all the assessed PA outcomes. This further suggests that for the current sample, autonomous motivation, and especially intrinsic motivation, was a more prominent behavioural regulation, which is in line with what has previously been reported for healthy college-age individuals (Sibley et al., 2013) and adults (Teixeira et al., 2012).

External regulation was a negative predictor of PA frequency, showing that being motivated to exercise to achieve external rewards or avoid punishment will decrease how often adults are physically active, and thus their cardiorespiratory fitness. A negative relationship between external regulation and both PA and VO_{2peak} has been reported in previous studies (Mikkelsen et al., 2022; Teixeira et al., 2012; Videm et al., 2022) and appears to be stronger for men than women (Teixeira et al., 2012). Even though the β-values are relatively low, external regulation draws in the opposite direction compared to more autonomous forms of motivation, underlining the possible detrimental impact controlled motivation could have on PA behaviour.

In summary, the results of the regression analyses implied that the participants were to a large extent characterised by self-determined motivation to engage in PA. The amotivation factor was not associated with any of the physical activity outcomes, which is expected since the participants were recruited among members of a sports organisation. Intrinsic motivation was the most important motivation factor for physical activity and was significantly related to all the outcomes studied. This regulation subtype refers to activities that are enjoyable and satisfying in themselves and given the high level of activity reported by the sample it is not surprising that the participants experience a high degree of mastery reward from their activities. One could also argue that external regulation is of great importance since it negatively impacts PA frequency and eCRF. Clearly this type of controlled motivation has a negative impact on PA behaviour and should be avoided if possible.

Limitations

The study was conducted during the COVID-19 pandemic, and this may have influenced the findings of the current study. During the pandemic there were studies reporting reduced physical activity and motivation due to the social distancing rules (Corpus et al., 2022; Romero-Blanco et al., 2020), and we cannot know if the social distancing rules affected the participants' degree of motivation. Furthermore, in Norway the social distancing rules were to some extent decided by municipality authorities, which means that there were some regional differences in what social distancing regulations were applied, and the participants did not report their geographical location. BMI was calculated from self-reported hight and weight which could have biased the accuracy of eCRF. Still, recent findings suggest that BMI based on self-reported height and weight are reasonable accurate (Haakstad et al., 2021). The study sample was highly physically active and predominantly male (Anyan et al., 2020), which means that the results may not be generalisable to more heterogeneous samples or less active populations, and samples with a majority of women.

Conclusion

This study found support for the 18-item BREQ-2 with item 19 "I get restless if I don't exercise regularly" removed. Other competing versions of BREQ tested in the current study did not outperform BREQ-2 in terms of model to data correspondence, including the original 15-item BREQ, the 19-item BREQ with integrated regulation and the 18- and 24-item BREQ-3. Except for the amotivation subscale, the factors were associated with physical activity outcomes and the 18-item BREQ-2 appears to be a suitable measure of behavioural regulations for physical activity in highly active adult Norwegian samples.

Ethics approval and consent to participate

The study was approved by the Regional Committees for Medical and Health Research Ethics (reference number 139169) and the Norwegian Centre of Research Data (reference number 894064). The participants provided written informed consent to participate in this study.

Consent for publication

The participants provided written informed consent for publication of the study.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

Data are available on reasonable request from the corresponding author.

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