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The Role of Physical Activity Behavior in the Mental Wellbeing of Vocational Education and Training Students: The PHIT2LEARN Study

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A positive association has been found between physical activity (PA) and student mental wellbeing (SMW). This association has been mainly explored in secondary school and university students. Studies in vocational education and training (VET) are lacking, while VET students could especially benefit from exploring this association since research shows that VET students, who often come from low socioeconomic status (SES) households, are prone to low SMW. Low SMW can result in higher school dropout rates and long-term negative effects, such as unemployment, social exclusion, and impoverishment. The aim of the current study was to explore the association between total PA and different physical activity behaviors {PABs, i.e., moderate to vigorous physical activity (MVPA), light physical activity (LPA), and sedentary behavior (SB)}, and SMW in the VET setting. In this cross-sectional observational study, students wore an ActivPAL3^{TM} accelerometer for 7 consecutive days to measure PAB. SMW was assessed using the Center for Epidemiologic Studies Depression Scale (CES-D) and the Rosenberg self-esteem questionnaire (RSE). Complete data for the analyses were obtained from 85 students. Multiple regression analyses showed a significant positive association between total PA and self-esteem and a significant negative association between total PA and depressive symptoms. Taking different PA intensities into account, there was a significant positive association between LPA and self-esteem and a significant negative association between LPA and depressive symptoms. No significant associations were found between MVPA and the outcome measures, although the associations were aligned with the findings for LPA. High levels of SB were significantly associated with low self-esteem; however, the association between SB and depressive symptoms was not significant. The significant positive associations between LPA and SMW and the negative association between SB and self-esteem indicate that decreasing SB and increasing LPA could contribute to improve SMW. Future research should determine if these are causal relationships.

Keywords: vocational education and training, physical activity behavior, sedentary behavior, student mental wellbeing, self-esteem, depressive symptoms, observational design

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INTRODUCTION

Student mental wellbeing (SMW) is receiving increasing research attention (Dopmeijer et al., 2018; Doornwaard et al., 2021; UNICEF, 2021; Van der Maden et al., 2021). SMW is defined as: "a sustainable state characterized by predominantly positive feelings and attitude, positive relationships at school, resilience, self-optimization, and a high level of satisfaction with learning experiences" (Noble et al., 2008, p. 30). SMW encompasses among others, the absence of depressive symptoms and having high levels of self-esteem (Noble et al., 2008; Schoemaker et al., 2019). Developing depression is a major problem among students, the point prevalence of increased depressive symptoms is globally 37% for 10–19 year olds (Shorey et al., 2021). While prevalence rates for low self-esteem are scarcer, Nguyen et al. (2019) measured self-esteem using the Rosenberg self-esteem questionnaire (RSE) and found that 19% of secondary school students in their sample had low self-esteem (i.e., a score lower than 15). Having low SMW is associated with less academic success and significantly higher school dropout rates, which can eventually result in unemployment, social exclusion, and impoverishment (Andrews and Wilding, 2004; Amholt et al., 2020; European Commission, 2020). It has been suggested that SMW can be improved by increasing physical activity behavior (PAB; Hoare et al., 2016; Korczak et al., 2017). While several studies in primary school, secondary school, and university students indicate that higher PAB is associated with higher SMW (Hoare et al., 2016; Korczak et al., 2017; Zayed et al., 2018; Tamminen et al., 2020), within the vocational education and training (VET) setting this association has not yet been established.

Physical activity behavior is defined by Caspersen et al. (1985) as "any bodily movement produced by skeletal muscles that result in energy expenditure" (p. 126) and can be measured in Metabolic Equivalent of Task (MET), which is the amount of oxygen the body uses for an activity (Jetté et al., 1990). It is often categorized into four intensity levels, namely, vigorous physical activity (VPA), such as running and competitive sports, moderate physical activity (MPA), such as brisk walking or light effort cycling, light physical activity (LPA), for example, desk work and standing, and sedentary behaviors (SB), such as sitting, reclining, or lying (Haskell et al., 2007). In PAB guidelines, MPA and VPA are often combined into one category: moderate to vigorous intensity physical activity (MVPA; Nakagawa et al., 2020).

The relationship between PAB and the sub-concepts of SMW, (lack of) depressive symptoms and self-esteem, has been investigated in several studies (Hoare et al., 2016; Korczak et al., 2017; Biddle et al., 2019; Costigan et al., 2019). There are several studies that report the relationship between total physical activity (PA) (i.e., MVPA and LPA combined) and depressive symptoms and self-esteem (Tremblay et al., 2000; McKercher et al., 2009; Salmon et al., 2011; Gunnell et al., 2016; Van Dijk et al., 2016; Gianfredi et al., 2020; Kandola et al., 2020). However, because PA can be divided into separate intensities that might differently affect SMW, we also analyzed the separate PAB intensities.

Korczak et al. (2017) reviewed 28 cross-sectional studies on the relation between MVPA and depressive feelings and concluded that there appears to be a negative association between MVPA and depressive symptoms. Kandola et al. (2020) found a similar negative significant association in their longitudinal study. Additionally, in several studies in primary and secondary school students and adults, a positive significant association between MVPA and self-esteem was found (Tremblay et al., 2000; Parfitt and Eston, 2007; Fedewa and Ahn, 2011; Zamani Sani et al., 2016).

The relationship between LPA and depressive symptoms is studied less extensively, and the results of the studies in which this relationship is investigated are equivocal (Costigan et al., 2019; Xiang et al., 2020; Hagemann et al., 2021). For example, no significant association was found between LPA and depressive symptoms among 1,223 and 934 secondary school students (Costigan et al., 2019; Hagemann et al., 2021), whereas Xiang et al. (2020) found a significant negative correlation between LPA and depressive symptoms in 428 secondary school students. Moreover, in a longitudinal study, depression scores were significantly decreased with every 60 min of increase in LPA (Kandola et al., 2020). To our knowledge, there is only one study in which the association between LPA and self-esteem is investigated (Goding and Petzén, 2018). In this study, no significant association between LPA and self-esteem was shown among 268 university students.

The relationship between SB and both depressive symptoms and self-esteem has been summarized in a review by Hoare et al. (2016). They included 32 studies in their review and described that there seems to be a positive association between SB and depressive symptoms and a negative association between SB and self-esteem in the adolescent population. Moreover, longitudinal studies by Gunnell et al. (2016) and Kandola et al. (2020) report that high levels of SB and consistently low levels of LPA are significantly associated with more depressive symptoms.

Many of the studies on the association between PAB and SMW used questionnaires to measure different types of PAB (Hoare et al., 2016; Korczak et al., 2017; Goding and Petzén, 2018) and questionnaires on screen time as a proxy for SB (Hoare et al., 2016). This could lead to an over or under representation of the amount of time spent in these behaviors (Schilling et al., 2018).

In the current study, we measured total PA and all different PAB intensities separately by accelerometry using a 24-h measurement protocol, allowing us to capture all time spent in MVPA, LPA, and SB and to determine how these are associated with SMW. Additionally, many of the studies on PAB and SMW have been carried out in secondary schools (Eddolls et al., 2018; Costigan et al., 2019), colleges (Adams et al., 2005; Zhang et al., 2020), or universities (Joseph et al., 2014; Schultchen et al., 2019). Thus, to our knowledge, the relation between PAB and SMW has never been explored within the VET setting. Advanced insights in this population are of added value to the current knowledge base since, for example, a substantial part (40%) of the Dutch tertiary school-going population is enrolled in VET (CBS, 2020) and many VET students are from low socioeconomic status (SES) households (Kennisplatform onderwijs, 2018). Being from low SES households makes VET students more prone to SMW problems, due to a higher exposure to stressful life events [e.g., divorce, financial crises, and (mental) illness within the

family] than students from households with a higher SES (Stevens et al., 2018; Reiss et al., 2019). As a result, VET students are more susceptible to dropping out of school (Hjorth et al., 2016; Stevens et al., 2018; European Commission, 2020). In addition, low SES groups, such as VET students, are vulnerable to engage in insufficient PA (Rijpstra and Bernaards, 2011; Grüne et al., 2020), therefore, exploring this relationship could be of importance. Furthermore, besides possible mental wellbeing benefits, PA has also health benefits (Bull et al., 2020). Therefore, the aim of the current study was to explore the association between total PA and SMW and PAB of different intensities (i.e., MVPA, LPA, and SB) and SMW in the VET setting. It is expected that high levels of PA are associated with higher levels of SMW, the same is expected for the association between MVPA and SMW, and high levels of SB are associated with lower levels of SMW. Previous research shows that the relationship between LPA and SMW is less clear, thus, there is no expectation regarding the association between LPA and SMW.

MATERIALS AND METHODS

Study Design

The current cross-sectional observational study is a part of the "PHysical activity InTerventions to enhance LEARNing in VET" (PHIT2LEARN) study. The PAB of students was measured, students executed a number of cognitive tests, and they filled out a number of questionnaires. In the current study, the associations between objectively measured PAB and SMW in VET students are reported, the results regarding the cognitive measures have been reported elsewhere (Golsteijn et al., 2021).

Participants

Participants were recruited using a purposive sampling method (Ritchie et al., 2013) at a VET school in the south of the Netherlands that offers the full range of VET education. In consultation with the management of the school, 374 students (19 classes) were approached. Some of these students were going to school and following internships, while others did not have their internships yet. There were no exclusion criteria formulated, however, students who indicated that they took medication that could influence their SMW were excluded from the data analyses.

The sample size calculation was performed using G*Power for linear multiple regression (fixed model, R^2 increase) (Universität Düsseldorf, Düsseldorf, Germany). The power analysis was based on the results of the study of Zhang et al. (2020) who utilized the positive and negative affect scale to measure positive and negative affect. However, as both, the Center for Epidemiologic Studies Depression Scale (CES-D, i.e., the scale utilized in the current study) and the positive and negative affect scale, include positive and negative affect, we utilized the results of the study of Zhang et al. (2020) to execute the sample size calculation. To calculate the effect size f^2, the Pearson correlations between MVPA and the outcomes positive and negative affect (0.15 and −0.05) and the Pearson correlations between VPA and positive and negative affect (0.21 and −0.17) were transformed to R^2 using an online effect size converter (Effect Size Converter, n.d.), which led to an R^2 of 0.03, 0.003, 0.04, and 0.02. These R^2 were added up leading to an R^2 of 0.098. This R^2 was then entered into G*Power (variance explained by a special effect) and the f^2 was calculated, this led to an f^2 of 0.11, which is approximately a medium effect size. Using an f^2 of 0.11 and an alpha of 0.05, 75 participants were needed to achieve a power of 0.8.

Procedure

The study was approved by the Research Ethics Committee (cETO) of the Open University of the Netherlands (U2017/00519/FRO) and has been registered in the Dutch Trial Register (NTR6358), which is connected to clinicaltrials.gov. After approval from the cETO, for each participating class, three research sessions were planned in three consecutive weeks (March to July 2017) in agreement with the management of the school. During the first session, the researchers held a presentation to inform all students on the procedure of the study. The presentation emphasized that participation was voluntary, that all data would be coded and stored securely, and that students could opt out at any given moment. Afterward, all potential participants received an information letter and informed consent form, which they returned before the start of the second session 1 week later. According to Dutch ethical regulations (National Ethics Council for Social and Behavioural Science, 2018), 16–18 years olds had to inform their parents but could decide and sign the informed consent themselves. Participants aged 18 years or older decided themselves.

During the second session, the participants who gave consent were instructed to attach an accelerometer to the middle anterior part of their right thigh in a private room. Participants (optionally) shaved the middle of the anterior part of their right thigh and taped a waterproofed ActivPAL3^{TM} (PAL Technologies Ltd., Glasgow, United Kingdom) accelerometer on their thigh using Tegaderm^{TM} (3M, Saint Paul, MN, United States) transparent film roll. Participants were asked to wear the accelerometers until the third session (1 week later). After attaching the ActivPAL3^{TM}, the height and weight of the participant were measured to determine their body mass index (BMI). Additionally, all participants filled out a questionnaire regarding general information (i.e., sex, age, current education level, education level of their parents/caregiver, health, and pubertal status).

The third session started with a presentation on what to expect during that session, after which all participants filled out questionnaires regarding their depressive feelings and self-esteem. While students filled out the questionnaires, they were asked to leave the room one by one to remove the accelerometer they had worn and hand it over to the researchers.

Measurements

Physical Activity Behavior

To objectively measure PAB, participants were asked to wear an ActivPAL3^{TM} accelerometer. The ActivPAL3^{TM} is a uni-axial wearable device (53 mm × 35 mm × 7 mm) that detects limb position on three axis (*x*-, *y*-, and *z* axis) and accordingly identifies the wearer's posture. The ActivPAL3 was

worn continuously without taking it off for water activities (e.g., showering or swimming). Data were recorded at 20 Hz and summarized in 10-s epochs. In a free-living situation, the inter-device reliability ranged between 0.79 and 0.99 (Grant et al., 2006), and the overall agreement between observer and ActivPAL3 was 95.9% (Sellers et al., 2016).

The students that had regular classes and internships were asked to wear the accelerometers for 10 consecutive days, and students that were not doing internships were asked to wear the accelerometers for 7 consecutive days. This was to make sure that the same number of schooldays was recorded. Afterward all data were downloaded from the ActivPAL3. Processing PAL (Edwardson and Ette, 2019) was then used to process the data.

Based on METs, PAB is in this study classified into three intensity levels, namely, MVPA (>3 MET), LPA (1.6–2.9 MET), and SB (≤1.5 MET) (Haskell et al., 2007; Nakagawa et al., 2020).

Data were considered valid if 2 valid week- and 2 valid weekend days were recorded (Trost et al., 2005). From all valid days, the average hour per day per outcome [i.e., MVPA stepping, LPA stepping, standing (LPA), time spent sedentary (sitting/lying), and time in bed] was calculated. Thereafter, average hours per day of total PA (i.e., MVPA and LPA combined), MVPA, LPA, and SB were calculated per participant.

In addition, the SB ratio was calculated. This SB ratio is an indication of interrupted sitting behavior and is obtained by calculating the ratio between time spent sedentary in bouts shorter than 30 min and the total average SB per day. A high ratio indicates that SB is interrupted more often. This 30 min cutoff is based on the recommendation to interrupt SB every 30 min (Rutten et al., 2013).

Student Mental Wellbeing

As in this study, SMW was operationalized as the absence of depressive symptoms and the presence of self-esteem; two well-validated questionnaires were used to measure these concepts. The absence of depressive symptoms was measured using the Dutch version of the CES-D (Radloff, 1977). The CES-D consists of 20 questions. Students indicated how often they felt a certain way in the previous week on a 4-point scale ranging from rarely to all the time [i.e., 0 = rarely or never (i.e., less than 1 day), 1 = some or a little of the time (i.e., 1–2 days), 2 = occasionally or a moderate amount of the time (i.e., 3–4 days), or 3 = all of the time (i.e., 5–7 days)]. An example of a question is "I felt depressed." Four items are worded positively and thus scored reversely. Thereafter all items were summed to calculate a total score that ranged from 0 (not depressed/absence of depressive symptoms) to 60 (depressed/high number of depressive symptoms). A score of ≥16 is an indication for depression (Beekman et al., 1997) and a score of ≥22 indicates severe to major depression (Cuijpers et al., 2008). The scale has very good internal consistency (alpha 0.85), satisfactory test-retest reliability (0.51–0.67 over 2- to 8-week period, 0.32–0.54 over 3–12 months), and good convergent and construct validity (Radloff, 1977).

Self-esteem was measured using the Dutch version of the Rosenberg self-esteem scale (RSE; Rosenberg, 1979), which consists of 10 statements dealing with general feelings about how students feel about themselves. The participants had to indicate whether they agreed with the statement on a four-point Likert scale ranging from strongly agree to strongly disagree (i.e., 0 = strongly agree, 1 = agree, 2 = disagree, or 3 = strongly disagree). An example of such a statement is "On the whole, I am satisfied with myself." Five positive items were scored reversely. All items were summed to calculate a total score that ranged between 0 and 30, a higher score indicates a higher global self-esteem. The scale has been reported to have a satisfactory reliability of 0.72–0.88 (Gray-Little et al., 1997).

Body Mass Index

Body mass index was calculated for each participant by the formula $\frac{weight\ in\ kilograms}{height\ in\ m^2}$. All students were weighed using a body composition monitor (Karada Scan, Omron, BF511) after emptying their pockets and undressing as much as possible (e.g., removal of caps, shoes, and jackets). Afterward, students' height was measured by a member of the research team using a measuring tape.

Other Variables

The students had to fill out several questionnaires regarding background variables that could act as covariates, such as SES, smoking, alcohol intake, and questions on physical disabilities that could influence their PAB or medication that could influence SMW. SES was measured by asking students what the highest education level of their father, mother, and/or caregiver(s) was. Students were asked to estimate how many cigarettes they smoked a week and how many days a week they drank alcohol and to give an estimation on how many units of alcohol on average they drank on the days they consumed alcohol. Regarding physical disabilities that could influence PAB, students were asked if they were diagnosed with something that could influence their PAB, thereafter students were asked what the disability was and who diagnosed it. The same questions were asked regarding medication that could influence SMW.

Statistical Analyses

Analyses were performed using SPSS, version 26 (SPSS Inc., Chicago, IL, United States). Descriptive statistics were obtained using means and standard deviations (SD) for continuous variables and in numbers (N) and percentages for categorical variables and median for the score on the CES-D and RSE. To see if there were significant differences between the group included in the data analyses and the group excluded from the data analysis ANOVA's were performed for BMI, age, RSE score, and CES-D score and a chi-square was performed for sex. Prior to executing the multiple regressions, an assumption check indicated that all assumptions were met. The relationship between PAB and SMW was assessed using multiple linear regression with the ENTER method, forcing all variables at once in the model. The independent variable being total PA, MVPA, LPA, or SB and the dependent variables being total score on the CES-D (depressive symptoms) or total score on the RSE (self-esteem), followed by all covariates: BMI, sex (female/male), age, smoking, and alcohol use. These covariates were added since previous research has shown that these

were associated with PAB and SMW (Eddolls et al., 2018; Costigan et al., 2019; Tamminen et al., 2020). Additionally, the categorical covariate "disabilities that could influence PAB" (yes/no) was added to the model. The regression models do not control for the different PAB intensities. As the students used the accelerometer with a 24-h wearing protocol, time spent in different PABs is intrinsically collinear and PABs are codependent, even when they are uncorrelated according to correlation analysis (Pedišić, 2014; Chastin et al., 2015). Therefore, entering several PABs in one model would violate the assumption of no multicollinearity for executing regression analyses. For each independent variable, a separate multiple regression was carried out, with a total of five independent variables (i.e., average hours of total PA, MVPA, LPA, SB, and the SB ratio), thus resulting in a total of ten multiple regression analyses. All analyses with values of $p < 0.05$ were considered significant.

RESULTS

Participants

A total of 374 VET students were asked to participate in the current study, of whom 230 provided informed consent. Two students used depression medication and were excluded (**Figure 1**). A total of 225 students completed the first questionnaire, 175 completed the second questionnaire, and for 124 students, sufficient ActivPAL3 data were collected; some overlap in excluded data is possible. Thus, this resulted in valid data (e.g., filled out questionnaires and sufficient ActivPAL3 data) for 85 students. The characteristics of the included participants are presented in **Table 1**.

Of the 85 students, 60 (70.6%) were women and the mean age was 18.8 ± 2.8 years. For 13 (15.3%) students, there was an indication for depression (CES-D score between 16 and 21), 11 (12.9%) students were classified as having severe to major depression (CES-D ≥ 22). The mean score on CES-D was 12.4 ± 8.83 (median = 10) and the mean on the RSE was 19.79 ± 3.84 (median = 20). Total PA has a mean of 6.3 ± 1.6 h per day, MVPA has a mean of 1.4 ± 0.5 h per day, the mean of LPA was 4.9 ± 1.5 h a day, and the mean for SB was 8.3 ± 1.6 h per day. All other descriptive data are described in **Table 1**.

The group included in the data analysis differed significantly from the group excluded from the data analysis. Regarding BMI (23.9 ± 4.2; $p = 0.02$) and score on the RSE (21.5 ± 4.6; $p = 0.01$), statistically significant differences were found between the two groups. In addition, the distribution of women/men in the group included in the data analyses was significantly different from the distribution in the group excluded from the data analyses (50.7/49.3%; $p = 0.002$).

Association Between Total Physical Activity and Student Mental Wellbeing

The regression analysis for total PA and depressive symptoms (**Table 2**) revealed a significant negative association between total PA and depressive symptoms (β = −0.25, 95% CI = [−2.58, −0.16], $p = 0.03$). This indicates that with every hour increase in PA, students score 1.37 points lower on the CES-D questionnaire, thus having less depressive symptoms. Smoking and alcohol use were not included as covariates to this and all other multiple regression models, since these two variables had no significant contributions (all $p \geq 0.14$). Moreover, the two variables never significantly improved the regression model.

For self-esteem, the regression analyses revealed a significant positive association between total PA and self-esteem (β = 0.29, 95% CI = [0.19, 1.17], $p = 0.01$). This indicates that with every hour increase in total PA, students score 0.68 points higher on the RSE questionnaire, thus having higher self-esteem.

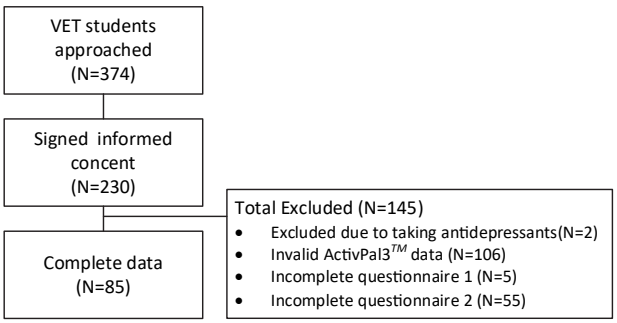

FIGURE 1 | Flowchart of participants. In the total excluded overlap is possible (e.g., a student could have incomplete questionnaire data and invalid ActivPAL3 data simultaneously).

TABLE 1 | Participants' characteristics.

	N	Mean or N (%)	*SD*
Age (years)	85	18.8	2.8
Female/Male	85	60/25 (70.6/29.4%)	–
BMI	85	22.64	3.29
Smoking yes/no	84	12/73 (14.1/85.9%)	–
1–70 cigarettes per week		11 (12.9%)	
>70 cigarettes per week		1 (1.2%)	
Alcohol yes/no	85	54/31 (63.5/36.5%)	
Alcohol units per week	85	4.9	10.2
Physical activity disability yes/no	85	7/78 (8.2/91.8%)	–
Score on CES-D symptoms	85	12.5 *Mdn* 10	8.8
Score on RSE	85	19.8 *Mdn* 20	3.8
Total PA	85	6.3	1.6
MVPA	85	1.4	0.5
LPA	85	4.9	1.5
SB	85	8.4	1.6
Time in bed	85	9.3	0.9

Cigarettes smoked categories obtained from Pierce et al. (1987). BMI, Body mass index; CES-D, Center for Epidemiologic Studies Depression Scale; RSE, Rosenberg self-esteem scale; Total PA, total physical activity; MVPA, moderate to vigorous physical activity; LPA, light physical activity; SB, sedentary behavior. Time in bed does not equal sleeping time, it could also be time awake that is spent lying down.

TABLE 2 | Regression analyses of total PA on depressive symptoms and self-esteem.

	Depressive symptoms R^2 = 0.10; adj. R^2 = 0.05				Self-esteem R^2 = 0.22; adj. R^2 = 0.17			
Variable	**B [95% CI]**	**SE B**	**β**	***p***	**B [95% CI]**	**SE B**	**β**	***p***
(Constant)	6.66 [−13.81, 27.14]	10.29		0.52	23.29 [14.98, 31.60]	4.17		<0.001
Total PA	−1.37 [−2.58, −0.16]	0.61	−0.25	0.03	0.68 [0.19, 1.17]	0.25	0.29	0.01
BMI	0.43 [−0.16, 1.02]	0.30	0.16	0.15	−0.27 [−0.51, −0.03]	0.12	−0.23	0.03
Sex	3.61 [−0.71, 7.94]	2.17	0.19	0.10	−3.35 [−5.11, −1.61]	0.88	−0.40	<0.001
Age	0.11 [−0.58, 0.80]	0.35	0.04	0.75	0.03 [−0.25, 0.31]	0.14	0.02	0.84
Physical disabilities	0.24 [−6.98, 7.46]	3.62	0.01	0.95	2.86 [−0.07, 5.79]	1.47	0.21	0.06

Total PA, Total physical activity; BMI, body mass index.

TABLE 3 | Regression analyses of MVPA on depressive symptoms and self-esteem.

	Depressive symptoms R^2 = 0.09; adj. R^2 = 0.03				Self-esteem R^2 = 0.17; adj. R^2 = 0.12			
Variable	**B [95% CI]**	**SE B**	**β**	***p***	**B [95% CI]**	**SE B**	**β**	***P***
(Constant)	6.35 [−14.65, 27.35]	10.55		0.55	24.18 [15.51, 32.86]	4.36		<0.001
MVPA	−4.12 [−8.58, 0.35]	2.24	−0.24	0.07	1.57 [−0.27, 3.41]	0.93	0.20	0.09
BMI	0.42 [−0.18, 1.02]	0.30	0.16	0.16	−0.26 [−0.51, −0.02]	0.12	−0.23	0.04
Sex	0.87 [−3.78, 5.51]	2.33	0.05	0.72	−2.19 [−4.10, −0.27]	0.96	−0.26	0.03
Age	0.07 [−0.63, 0.77]	0.35	0.02	0.84	0.44 [−0.24, 0.33]	0.15	0.03	0.76
Physical disabilities	1.11 [−6.07, 8.28]	3.60	0.04	0.76	2.30 [−0.67, 5.26]	1.49	0.17	0.13

MVPA, Moderate to vigorous physical activity; BMI, body mass index.

Association Between Moderate to Vigorous Physical Activity and Student Mental Wellbeing

Non-significant associations (**Table 3**) were found for MVPA and depressive symptoms (β = −0.24, 95% CI = [−8.58, 0.35], p = 0.07), and for MVPA and self-esteem (β = 0.20, 95% CI = [−0.27, 3.41], p = 0.09).

Association Between Light Physical Activity and Student Mental Wellbeing

The regression analysis for LPA and depressive symptoms (**Table 4**) revealed a significant negative association between LPA and depressive symptoms (β = −0.24, 95% CI = [−2.84, −0.01], p = 0.048). This indicates that with every hour increase in LPA, students score 1.43 points lower on the CES-D questionnaire, thus having less depressive symptoms.

For self-esteem, the regression analyses revealed a significant positive association between LPA and self-esteem (β = 0.29, 95% CI = [0.18, 1.33], p = 0.010). This indicates that with every hour increase in LPA, students score 0.75 points higher on the RSE questionnaire, thus having higher self-esteem.

Association Between Sedentary Behavior and Student Mental Wellbeing

The regression analysis regarding SB and depressive symptoms (**Table 5**) revealed a non-significant association between SB and depressive symptoms (β = 0.20, 95% CI = [−0.13, 2.39], p = 0.08).

For self-esteem, however, the regression analysis revealed a significant positive association between SB and self-esteem (β = −0.24, 95% CI = [−1.09, −0.06], p = 0.03). This indicates that with every hour increase in SB, students score 0.58 points lower on the RSE questionnaire, thus having lower self-esteem.

Association Between Sedentary Behavior Ratio and Student Mental Wellbeing

The regression analyses regarding SB ratio and depressive symptoms (**Table 6**) revealed no significant association between SB ratio and depressive symptoms (β = −0.18, 95% CI = [−32.98, 3.56], p = 0.11), a significant association was not found between SB ratio and self-esteem (β = 0.14, 95% CI = [−2.58, 12.55], p = 0.19). This indicates that an increase in SB ratio is not associated with an increase in SMW.

DISCUSSION

The aim of this study was to explore the association between total PA and SMW and PAB of different intensities (i.e., MVPA, LPA, and SB) and SMW in the VET setting. A significant negative association was found for total PA and depressive symptoms and a significant positive association for total PA and self-esteem. This indicates that every hourly increase in PA is associated with scoring 1.37 points lower on the CES-D questionnaire, thus having fewer depressive symptoms and 0.68 points higher on the RSE questionnaire, thus having higher self-esteem, respectively. This is in line with earlier research on total PA and depressive symptoms and self-esteem (Tremblay et al., 2000; McKercher et al., 2009; Salmon et al., 2011; Gunnell et al., 2016;

TABLE 4 | Regression analyses of LPA on depressive symptoms and self-esteem.

	Depressive symptoms R^2 = 0.09; adj. R^2 = 0.03				Self-esteem R^2 = 0.21; adj. R^2 = 0.16			
Variable	**B [95% CI]**	**SE B**	**β**	***p***	**B [95% CI]**	**SE B**	**β**	***p***
(Constant)	4.687 [−15.59, 24.96]	10.18		0.65	24.11 [15.90, 32.31]	4.12		<0.001
LPA	−1.43 [−2.84, −0.01]	0.71	−0.24	0.048	0.75 [0.18, 1.33]	0.29	0.20	0.010
BMI	0.41 [−0.18, 1.01]	0.30	0.16	0.17	−0.27 [−0.51, −0.03]	0.12	−0.23	0.03
Sex	4.25 [−0.32, 8.81]	2.29	0.22	0.07	−3.72 [−5.57, −1.88]	0.93	−0.26	<0.001
Age	0.12 [−0.58, 0.82]	0.35	0.04	0.73	0.02 [−0.26, 0.30]	0.14	0.03	0.87
Physical disabilities	0.57 [−6.66, 7.80]	3.63	0.02	0.88	2.76 [−0.17, 5.69]	1.47	0.17	0.07

LPA, Light physical activity; BMI, body mass index.

TABLE 5 | Regression analyses of SB on depressive symptoms and self-esteem.

	Depressive symptoms R^2 = 0.08; adj. R^2 = 0.02				Self-esteem R^2 = 0.19; adj. R^2 = 0.14			
Variable	**B [95% CI]**	**SE B**	**β**	***p***	**B [95% CI]**	**SE B**	**β**	***p***
(Constant)	−9.75 [−32.28, 12.78]	11.32		0.39	31.57 [22.37, 40.74]	4.61		<0.001
SB	1.13 [−0.13, 2.39]	0.63	0.20	0.08	−0.58 [−1.09, −0.06]	0.26	−0.24	0.03
BMI	0.41 [−0.18, 1.01]	0.30	0.15	0.17	−0.27 [−0.51, −0.02]	0.12	−0.23	0.03
Sex	3.27 [−1.07, 7.61]	2.18	0.17	0.14	−3.19 [−4.96, −1.42]	0.88	−0.38	0.001
Age	0.05 [−0.65, 0.75]	0.35	0.02	0.88	0.58 [−0.23, 0.34]	0.14	0.04	0.69
Physical disabilities	0.40 [−6.98, 7.78]	3.71	0.01	0.91	2.81 [−019, 5.82]	1.51	0.20	0.07

SB, Sedentary behavior; BMI, body mass index.

TABLE 6 | Regression analyses of SB ratio on depressive symptoms and self-esteem.

	Depressive symptoms R^2 = 0.08; adj. R^2 = 0.02				Self-esteem R^2 = 0.16; adj. R^2 = 0.11			
Variable	**B [95% CI]**	**SE B**	**β**	***p***	**B [95% CI]**	**SE B**	**β**	***p***
(Constant)	6.81 [−14.86, 28.49]	10.89		0.53	24.30 [15.33, 33.28]	4.51		<0.001
SB-ratio	−14.71 [−32.98, 3.56]	9.18	−0.18	0.11	4.99 [−2.58, 12.55]	3.80	0.14	0.19
BMI	0.43 [−0.17, 1.03]	0.30	0.16	0.16	−0.27 [−0.51, −0.02]	0.13	−0.23	0.04
Sex	2.85 [−1.45, 7.14]	2.16	0.15	0.19	−2.93 [−4.71, −1.15]	0.89	−0.35	0.002
Age	0.07 [−0.64, 0.77]	0.35	0.02	0.85	0.04 [−0.25, 0.34]	0.15	0.03	0.76
Physical disabilities	1.43 [−5.75, 8.60]	3.60	0.05	0.69	2.14 [−0.83, 5.11]	1.49	0.16	0.16

SB ratio, Sedentary behavior ratio; BMI, body mass index.

Van Dijk et al., 2016; Gianfredi et al., 2020; Kandola et al., 2020). Similar significant negative and positive associations were found for LPA and depressive symptoms and LPA and self-esteem, respectively. Every hour increase in LPA was associated with a 1.43 points lower score on the CES-D questionnaire, and 0.75 points higher on the RSE questionnaire. Additionally, a significant negative association was found for SB and self-esteem indicating that more sitting was associated with lower self-esteem. Even though we did not find significant associations between MVPA and the SMW outcomes, their directions were in line with our expectations, namely, that higher MVPA is negatively associated with depressive symptoms and positively with self-esteem. The same is the case for a positive association between SB and depressive symptoms.

Even though our findings are not consistent with the findings of the longitudinal study of Kandola et al. (2020) and the review of Korczak et al. (2017) who report a significant negative association between MVPA and depressive symptoms, they do largely concur with the findings of Tremblay et al. (2000), Parfitt and Eston (2007), Fedewa and Ahn (2011), and Zamani Sani et al. (2016) who reported a significant positive association between MVPA and self-esteem and the findings of Gunnell et al. (2016); Hoare et al. (2016), and Kandola et al. (2020) who state that there is a positive association between SB and depressive symptoms. The discrepancies in results could possibly be ascribed to a difference in how PAB is measured [e.g., questions on screen time (a proxy for self-reported SB) or self-reported PAB]. For instance, in the 28 cross-sectional studies included by Korczak et al. (2017), MVPA was mostly measured using self-report measurements (n = 26). The same is true for MVPA in the studies of Tremblay et al. (2000), Fedewa and Ahn (2011), and Zamani Sani et al. (2016), and in 16 out of 17 articles in the review of Hoare et al. (2016) on the association between SB and depression. Self-report measurements are susceptible to over- or underestimation of PAB behavior due to social desirable answers (Schilling et al., 2018). This notion is supported by

the fact that the two studies in the review of Korczak that assessed MVPA using accelerometers and the study of Hume et al. (2011) that measured SB using an accelerometer, similar to our study, did not show a significant association between MVPA/SB and depressive symptoms. Moreover, a possible reason why Parfitt and Eston (2007) reported a significant positive association between objectively measured MVPA and self-esteem is that they used a different type of self-esteem questionnaire (i.e., the Children and Youth Physical Self-Perception Profile) which measures a broad range of self-esteem concepts, while the RSE is correlated only with global self-esteem (Hagborg, 1993). This could be a possible explanation for finding different results.

The current study showed a significant association between LPA and SMW, meaning that higher LPA is associated with fewer depressive symptoms and higher feelings of self-esteem. Previous research on the relationship between LPA and SMW was inconclusive. Both Costigan et al. (2019) and Hagemann et al. (2021) found no significant association between LPA and depressive symptoms while Kandola et al. (2020) and Xiang et al. (2020), similar to our study, did find a significant association. A possible reason for Costigan et al. (2019) did not find a significant association could be that they included children in their study instead of adolescents, and since feelings of depression often emerge during adolescence (World Health Organization, 2020) it is likely that there were not many children with depressive feelings and it is thus harder to find a significant association. The difference between the results of the current study and that of Hagemann et al. (2021) could be explained by the accelerometer protocol they used. Hagemann et al. (2021) had participants who wear a Fitbit 2 for only 8 h a day, which might lead to an underestimation of LPA. To the best of our knowledge, only one other study (Goding and Petzén, 2018) examined the association between LPA and self-esteem in adolescents. Contrary to Goding and Petzén (2018), the current research showed a significant positive association between LPA and self-esteem, which could possibly be explained by the fact that the participants in the study of Goding and Petzén (2018) over or underestimated their self-reported PAB (Schilling et al., 2018).

The significant association found here for total PA, and more specifically LPA, and the different mental wellbeing outcomes could be explained by several mechanisms, namely, physiological, psychosocial, and behavioral mechanisms. Proposed physiological mechanisms of the relation between PAB and SMW are that increased PAB leads to an increased blood flow, which in turn activates different brain regions and therefore the release of different endorphins and monoamines, resulting in higher SMW (DeVries, 1981; Craft and Perna, 2004; Portugal et al., 2013; Lubans et al., 2016). It is also the case that the increase of body temperature caused by more PAB could lead to feelings of relaxation and reduction of muscular tension which in turn leads to higher SMW (Craft and Perna, 2004). Psychosocial mechanisms suggested to be involved include the fact that PAB can increase SMW by social reward [i.e., doing activities that increase PAB together with other people, such as walking (LPA)] and self-efficacy (i.e., feelings of competence, for instance, being able to complete a certain activity) (Lubans et al., 2016; Szabo et al., 2018). It also has been suggested that a change in appearance due to increased PAB could lead to feelings of autonomy (e.g., by following through on changing your PAB pattern) and contentment with body appearance (Craft and Perna, 2004). Lastly, it has been proposed that behavioral mechanisms are involved in positive SMW due to an increase of PAB, for instance, more PAB, such as walking or standing (LPA), could lead to improvement in sleep quality which in turn could improve SMW (Ellingson et al., 2018).

Moreover, we did find a significant negative association between SB and self-esteem. The significant negative association between SB and self-esteem mentioned in the systematic review by Hoare et al. (2016) is in line with the results of the current study, though the four studies included in their review utilized self-report. To our knowledge, the current study is unique in finding an association between objectively measured SB and self-esteem (Hoare et al., 2016).

Lastly, we explored the association between SB ratio and SMW, based on the recommendation by Rutten et al. (2013) that SB should be interrupted every 30 min. To our knowledge, the association between the SB ratio and SMW has not been explored before. We did not show a significant association between SB ratio and SMW. This indicates that it possibly does not matter if the time spent sedentary is all at once or interrupted by PAB.

Within the current study, all waking wear-time per student was measured with the ActivPAL3 and divided into total PA, MVPA, LPA, and SB. This provides us with comprehensive insights into PAB since decreasing one behavior, for example, SB, should automatically result in increasing one of the other behaviors (i.e., LPA or MVPA). The significant positive associations between higher LPA and SMW and the negative association between SB and SMW indicate that decreasing SB and increasing LPA could contribute to improved SMW. A possible way to reduce SB could be to exchange time spent in sitting for time spent in standing, in LPA or MVPA. Standing has a MET value of 1.59–1.71 (Mansoubi et al., 2015) and can therefore be classified as LPA. Replacing sitting for LPA, such as standing or movement breaks, is especially useful in the educational setting, as studies have shown that students are sedentary most of their time in school (Morton et al., 2016; Golsteijn et al., 2021). To promote standing in the educational setting, replacing traditional desks with standing desks or introducing movement breaks could be options. The current study could be used as starting point to explore the causal relationship between different PABs and SMW in the VET setting by conducting randomized controlled trials (RCT) to explore the effects of, for instance, the use of standing desks or movement breaks on SMW. In the long run, such interventions might lead to lower school dropout and fewer adverse long-term effects, such as unemployment, social exclusion, and impoverishment (Andrews and Wilding, 2004; Amholt et al., 2020; European Commission, 2020).

Strengths and Limitations

To our knowledge, this study is the first study in which the association between PAB and SMW in the VET setting is explored. The findings can be used as a starting point to set up an RCT. Another strength of this study is that PAB was measured using an accelerometer. In comparison to other observational studies, the current study looked at the total waking wear-time divided over SB, LPA, and MVPA by using an accelerometer

instead of questionnaires on PAB and screen time, in which PAB is often over or underestimated due to socially desirable answering (Schilling et al., 2018).

Although we experienced a relatively large dropout in the current study, it can be considered as a well-powered study as the number of students who were included was sufficient to achieve a power >80%. Because of the high amount of dropouts due to insufficient data, we considered multiple imputations, however, due to the amount of missing data (i.e., more than 5%), this would not be reliable (Jakobsen et al., 2017). There were some significant differences between the group included in the data analyses and the group excluded from the data analyses, however, it should be noted that for the score on the RSE, this is not a clinical difference but a statistical difference. When considering BMI, it should be noted that students with a higher BMI tend to dropout of studies earlier (Kaiser et al., 2014), however, within the group excluded from the data analysis, BMI is still within the healthy range. Furthermore, we omitted SES from the analyses because we obtained this variable by asking students what the highest level of education of their parents or caregivers was. As some students did not know the educational level of their parents or caregivers, some students had several caretakers (e.g., due to divorces), and others no longer lived with a parent or caregiver, this resulted in a large amount of missing data. Altogether, as the obtained data on SES were of questionable reliability, SES was not added as a covariate in the multiple linear regression model. Therefore, for future research, it is recommended that SES information is provided by parents or caregivers or by the students themselves, when they live independently. It is also important to mention that the current study is an observational cross-sectional study. It is thus is impossible to draw causal conclusions, however, the results of this study can be used as a starting point to explore the presence of a causal relationship. Due to performing multiple regression analyses, it is possible that our results are at risk for a type I error. Although this could have been tackled by correcting for multiple testing, we decided not to do this, since applying such corrections is subject to debate (Bender and Lange, 2001).

Conclusion

The main results of this study indicate that there is a significant association between total PA and SMW. When taking different PABs into account, it seems that this association is strongest for LPA. This study makes a major contribution to the limited amount of research regarding the association between different PAB intensities and SMW. Additionally, a significant negative association between SB and self-esteem was found. Although no significant associations between MVPA and SMW and between SB and depressive symptoms were found, they were in the same line of expectations. Future research should focus on the possible causal relationships between changes in PAB and SMW by setting up RCTs by, for instance, introducing standing desks or movement breaks.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors on request, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Research Ethics Committee (cETO) of the Open University of the Netherlands (U2017/00519/FRO) and has been registered in the Dutch Trial Register (NTR6358), which is connected to clinicaltrials.gov. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MK, RGo, RGr, and HS contributed to the conception and design of the study. MK organized the database, performed the statistical analysis, and wrote the first draft of the manuscript. IW, RGo, RGr, and HS supervised and reviewed the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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