

The Shirom-Melamed Vigor Measure for students and how vigor relates to academic performance, mental health and satisfaction with life: Factorial analysis and construct validity in Spanish undergraduate university students

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Research

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Abstract

Background

Students suffer from a decrease in physical activity during their education period. This lower level of activity could affect, through various paths, their academic performance, mental health and satisfaction with life. In this study, we assume that vigor, a positive affect variable, would act as a mediating variable in the above relationship, and thus, we propose an instrument for evaluating vigor in academic contexts. To attain this aim, the factorial validity and reliability of the proposed vigor scale for students is tested (Study 1), along with its construct validity (Study 2).

Methods

In Study 1, 707 undergraduates (59.7% women) responded to the vigor scale adapted for students to test factorial validation (through confirmatory factor analysis) and obtain reliability indicators. In Study 2, 309 undergraduates (55.3% women) completed a questionnaire measuring physical activity, mental health, satisfaction with life, vigor and academic performance to test a structural model of the relationships between the variables to obtain construct validity.

Results

A measurement model with three related factors, each representing one dimension of vigor, optimally fit the data ($S-B\chi^2 = 231.54$; $df = 50$; $CFI = 0.95$; $NNFI = 0.93$; $SRMR = 0.07$; $RMSEA = 0.07 [0.06-0.08]$), and the reliability indices were adequate (Study 1). In Study 2, the mediational model confirmed a complete influence of physical activity on satisfaction with life, academic performance and mental health levels through the levels of vigor of the students, with optimal adjusting values ($S-B\chi^2 = 108.82$; $df = 62$; $p < 0.001$; $CFI = 0.92$; $NNFI = 0.90$; $SRMR = 0.05$; $RMSEA = 0.05 [0.03-0.06]$).

Conclusions

Proposing an instrument such as the Shirom-Melamed Vigor Measure for students allows the opening of a research venue that is focused on the study of positive affects in academic contexts, as well as the testing of the physical activity pathways of action in obtaining positive results.

Background

In addition to the beneficial effects on physical health [1–3], performing physical activity (PA) in adulthood is related to a reduced risk of mental ill-health [4] and has been shown to be effective in reducing symptoms associated with depression [5,6]. Going beyond a clinical approach and considering

mental health (MH) as a positive state of well-being related to an optimal psychological experience and functioning [7], there are several studies that find a positive relationship between PA and satisfaction with life (SWL) [8–10], that is, the extent to which people value their present situation as an ideal situation [11]. Cognitive function is also positively affected by performing PA [12,13], and positive relationships have been found between PA and academic performance (AP) in academic contexts, such as university [14,15].

Despite the relationships found between PA and different outcomes in MH, SWL and AP, the underlying mechanisms of this association are not fully understood [16–18]. In this vein, conceptual models such as that of Lubans et al. [19] are of great interest in identifying the neurobiological, psychosocial, and behavioral mechanisms that mediate the effects of PA on outcomes such as cognitive function, well-being and ill-being. There is a rooted tradition in the study of biological and/or neuronal factors that intervene in the positive effects derived from performing PA [20] compared to the inclusion of emotional or affective factors, even though affect has shown its usefulness in the explanation of results in health, educational and work contexts, among others [21–23]. In the workplace, the positive and energetic affect known as vigor [24,25], which is defined as “a positive affective response to one's ongoing interactions with significant elements in one's job and work environment that comprises the interconnected feelings of physical strength, emotional energy, and cognitive liveliness” (p. 143) [24], has turned out to be a mediating variable of interest in the relationship that a group of personal and work resources [26] have with work satisfaction [27–29], MH [30] and performance at work [28,31,32], among others. Academic work and the context in which it is performed show similarities with work activity and the framework in which it occurs, that is, the organization [33]. In fact, constructs whose origins are situated in an employment context (burnout, engagement, organizational justice, etc.) have been successfully used in academic contexts [34,35]. Considering vigor at work [24] in academic contexts could help to understand the psychosocial-type mechanisms by which PA exerts its effect on cognitive function, health and well-being.

Currently, there is no measure in academic contexts that allows the evaluation of vigor from the perspective of Shirom [24,25]. The Shirom-Melamed Vigor Measure (SMVM) [24] assesses vigor at work, but it is designed for workers. The SMVM has recently been adapted to different countries [29,36] but its psychometric properties have not been analyzed in academic contexts.

In sum, the aim of this paper is twofold: 1) to determine the factorial structure and reliability of the SMVM in students, namely, the SMVM for students (SMVM-S) (Study 1); and 2) to analyze the construct validity of the SMVM-S by testing a structural model of the relations among PA, AP and MH by including vigor as a mediator (Study 2).

Study 1: Validation of the factorial structure of SMVM-S

This study was performed to analyze the factor structure, validity and internal consistency of the SMVM in the university context.

Methods

Design, participants and procedure

A cross-sectional survey was performed and completed by undergraduates from several degree programs at different Spanish universities. Participation was voluntary, and informed consent was obtained. The participants were recruited by fourteen students in their last year of psychology study from the Official Masters Program of Positive Psychology at the University of Jaén (Spain), who were instructed about the procedure and the distribution of the questionnaires. Seven hundred and seven participants (out of 709 initial; 2 were eliminated due to incomplete data) completed the SMVM-S questionnaire and the other scales during the second semester of the academic year. The participants' mean age was 21.1 years (SD=2.9; range 17 to 48 years) and 59.7% of them were female.

Measures

Demographics

The students reported their sex, gender, grade they were enrolled in, and their university of origin.

Vigor

Stemming from the Shirom-Melamed Vigor Measure (SMVM) [24] and its Spanish adaptation [36], items were modified by substituting the content referring to employees and/or clients with the term "class mates". The participants had to indicate how often in the past 30 days they had felt a number of different feelings while studying. The scale consisted of 12 items that comprised three dimensions: physical strength (5 items; i.e., "I feel full of energy"), cognitive liveliness (3 items; i.e., "I feel I can think rapidly") and emotional energy (4 items; i.e., "I feel able to show warmth to others"). The response format ranged from 1 (almost never) to 7 (almost always). The scale yielded an adequate reliability, with ρ values of 0.87, 0.73 and 0.83 [36].

Data analysis

Confirmatory factor analysis (CFA) determined the factorial structure and the goodness of fit of the different models of measurement. The violation of the assumption of multivariate normality of the data (Mardia's coefficient=36.79) suggested the use of a robust method of maximum likelihood (ML Robust) with EQS 6.4 software. As indicators of the goodness of fit of the measurement models to the data, the corrected χ^2 by Satorra-Bentler (S-B χ^2), NNFI, CFI, RSMR, and RMSEA, as well as their 90% confidence intervals (90% CI) were used. An acceptable model fit was defined as NNFI and CFI values close to 0.95 or greater, a SRMR value close to 0.08 or below, and a RMSEA value less than 0.08 [37,38]. The reliability of the dimensions of the instrument were examined by ρ [39], with 0.70 as an acceptable cut-off value [40]. The composite reliability (CR) and average extracted variance (AVE) were analyzed as indicators of internal consistency and convergent validity of the variables included, respectively. Cutoff values considered acceptable were CR values over 0.70 and AVE values over 0.50 [41]. Moreover, 0.6% of the

values for all the variables were missing. Missing data were imputed using the expectation maximization algorithm in IBM SPSS for Windows v22.0 after checking that the missing values were completely random using Little's MCAR test [42] ($\chi^2=22.67$; $df=43$; $p=0.995$).

Results

Table 1 shows the resulting adjustment values of the CFA for different measurement models. The measurement models proposed in the adaptation to Spanish of the SMVM [36] were tested, along with other models that have been confirmed in workers. Specifically, the other models included a model consisting of a single-factor structure (M1), a hierarchical model with three first-order factors representing the dimensions of vigor and a second-order factor (M2), a model with three related factors, each representing one dimension of different vigor (M3), a model equal to M3 but allowing the correlation of some error terms (M4), and a bifactor model (M5). The results show inadequate rates for M1 and M5. Models 2, 3 and 4 are nested models; thus, the differences in $S-B\chi^2$ when compared to each other show the best fit for M4. This model, proposed from the revision of the modification indices (MI), suggests the inclusion of a correlation between the error terms of items 4 and 5 of the SMVM-S.

Taking M4 as the model with a better fit to the data ($S-B\chi^2=231.54$; $df=50$; $p<0.001$; $CFI=0.95$; $NNFI=0.93$; $SRMR=0.07$; $RMSEA=0.07$ [0.06-0.08]), in Table 2, the standardized and nonstandardized coefficients of the measurement model are shown, as well as the indices related to reliability. All the standardized factor loadings are significant at $p<0.001$ and range from 0.61 to 0.96. Correlations between SMVM-S factors are all significant, with coefficients of 0.43 (physical strength-cognitive liveliness), 0.37 (physical strength-emotional energy) and 0.37 (cognitive liveliness-emotional energy). The indicators related to the reliability of the factors showed acceptable values in all cases.

Study 2: Construct validation

In this study, the validity of the construct was assessed by testing a structural model that analyzed the joint role of PA and vigor in undergraduates' MH, SWL and AP.

Methods

Design, participants and procedure

Data were obtained from a cross-sectional survey completed by undergraduates from several Spanish universities who were studying in different degree programs. Participation was voluntary, and the students provided informed consent. The participants were recruited over three months (February to April) by four Masters students (Official Masters Program in Positive Psychology and Official Masters Program of Research and Teaching in Physical Activity and Health Sciences from the University of Jaén) who were instructed about the procedure and distribution of the questionnaires.

Three hundred and nine participants completed this study (out of the initial 312; 3 were eliminated due to incomplete questionnaires). The participants' mean age was 22.1 years (SD=2.4; range 18 to 33 years), and 55.3% of them were female.

Measures

Demographics

The same data as those used in Study 1 were included.

Vigor

The same as that described in Study 1.

Physical activity

The International Physical Activity Questionnaire-Short Form (IPAQ-SF) [43] was administered. This instrument allows the calculation of the volume of total PA (walking, moderate and vigorous) over the last seven days by evaluating or assigning to each activity some energy requirements, which are defined as METs (multiples of the rate of metabolic expenditure), and it allows us to obtain a result in METs-minutes, that is, multiplying the result of the METs of an activity by the number of minutes during which it has been performed. A total MET-minutes per week number was obtained for each participant, where the highest values indicate a higher volume of total PA per week and therefore a higher energy consumption. The psychometric properties of the instrument have been evaluated in different countries and have obtained optimal values of reliability and validity in the adult population [43,44]. In Spanish undergraduates, the IPAQ-SF has shown to be a valid instrument when compared to objective measurements of PA obtained using accelerometers [45].

Mental health

The General Health Questionnaire (GHQ) [46] assesses normal healthy functioning to measure minor psychiatric morbidity and the appearance of new, distressing symptoms [47]. This study includes the 12 items version (GHQ-12) [48] adapted to Spanish [49]. This scale includes items such as "Could you concentrate as well as you used to?" that are responded to in a 4-point Likert format (ranging from 0=much more than usual to 3=not at all). Despite some controversy regarding the factorial structure of the instrument, studies with the Spanish population confirm a structure of three interrelated factors [50]: dysphoria, social dysfunction and loss of confidence. Other studies also confirm these factors [51,52]. A higher score indicates lower levels of health. In general, the Cronbach's alpha for Spanish samples is 0.76 [49].

Satisfaction with life

The Spanish version [53] of the Satisfaction with Life Scale (SWLS) [54] was included in the questionnaire. This instrument has an unidimensional structure and assesses the cognitive component

of subjective well-being [55]. On a 5-point Likert scale (ranging from 1=not at all to 5=absolutely), the participants responded to 5 items (i.e., "In most ways, my life is how I want it to be"). In the Spanish general population, the Cronbach's alpha value is 0.88 [53].

Academic performance

To evaluate AP, the students' grades were considered. The overall grade was determined as the weighted average of the final scores obtained in all subjects, with a range from 0 to 10, where 10 is the highest grade. Freshman students indicated their global score in access to university exams, which was recorded on a 14- to 10-point scale. In our sample, the range was from 5 to 9.21 points, with a mean grade of 6.98 (SD=0.93).

Data analysis

All analyses were performed with EQS 6.4 software for Windows. To avoid model estimation problems due to the disparate metrics of the variables, the items were rescaled by means of the percentage of proportion of maximum scoring (POMS) [56] using the observed maximum score in each variable. Due to the deviation of the data regarding the multivariate normality (Mardia's coefficient=10.29), the option ML Robust was used. The fit of the measurement model to the data was first verified by CFA. The model was shaped by five latent variables: vigor with three indicators (physical strength, cognitive liveliness and emotional energy), total PA with an indicator (MET-minutes per week), SWL with five indicators (each item of the scale), MH with three indicators (dysphoria, social dysfunction and loss of confidence) and AP with one indicator (average grade taken from the student record). For latent variables with a single indicator, the factor loadings were set with a value equal to one, and the variance of the error was estimated to fix it a priori [57]. Finally, a covariation was allowed between the error terms of two indicators of MH (dysphoria and loss of confidence) that would be theoretically justified [58]. The indicators of the goodness of fit of the models, as well as the criteria for deciding on their fit, were the same as those used in Study 1. Regarding the analysis of the structural model, following the theoretical mediational model of vigor at work [25] and theoretical proposals as Lubans' et al. [19], the fit of a group of nonnested structural models based on the CAIC index was compared. Lower values of the index corresponded to a better fit of the model, as long as the rest of the indices and their values met the decision criteria used in Study 1. Moreover, less than 3% of the values for all the variables on each scale were missing. Following the same procedure as that used for the missing data from Study 1, the missing values were imputed using the expectation maximization algorithm, since the missing values were completely random, and by using Little's MCAR test, para SMVM-S ($\chi^2=47.54$; $df=42$; $p=0.257$), GHQ ($\chi^2=72.34$; $df=66$; $p=0.277$), SWLS ($\chi^2=9.85$; $df=12$; $p=0.629$) and the average grade ($\chi^2=5.78$; $df=7$; $p=0.565$).

Results

The adjustment values of the measurement model tested were adequate (S-B $\chi^2=93.87$; $df=56$; $p<0.01$; CFI=0.93; NNFI=0.91; SRMR=0.04; RMSEA=0.05 [0.03-0.06]), resulting in all significant factor loadings

(values between 0.39 and 0.92).

Regarding the structural models, the M1 model or the saturated model was compared with the M2 (no direct effect), M3 (no effect from the predictor variable to the mediator) and M4 (no effect from the mediator to the outcome) models [59]. Table 3 shows the adjustment indices for each of the structural models, allowing the CAIC index, since they are nonnested models, and shows that M2 is the best model (CAIC=-308.643), that is, a model of total mediation in which the levels of PA exert their influence on academic results and levels of SWL and MH through the levels of vigor of the students. The fit indices of the M2 model show adequate values ($S-B\chi^2=108.82$; $df=62$; $p<0.001$; CFI=0.92; NNFI=0.90; SRMR=0.05; RMSEA=0.05 [0.03-0.06]). Figure 1 graphically displays the mediation model with the standardized regression coefficients and the percentage of variance explained in each endogenous variable. Total weekly PA levels were positively associated with student vigor levels, and vigor was positively related to SWL levels and AP and negatively related to the levels of MH (note that a higher score in MH implies a more deteriorated state of MH). The model explained 4% of the variance in the levels of vigor, 54% of the levels of SWL, 71% of the levels of MH and 6% of the AP. The indirect effects that total PA exerted through vigor on levels of SWL, levels of MH and AP were all significant ($\beta=-0.14$; $\beta=-0.16$; and $\beta=0.04$, respectively), thereby confirming the important mediating role played by the students' level of vigor in the relationship between the levels of total PA and other important results in academic contexts [60].

Discussion

Vigor at work has emerged as a positive affect variable, characterized by showing physical strength, cognitive liveliness and emotional energy at work [24], and helps to explain positive consequences at work [25]. In this research, we performed two studies to analyze the psychometric properties of the SMVM-S, an instrument to assess vigor levels in the academic context. Study 1 analyzes the fit to the data of different measurement models of the SMVM-S, as well as the reliability of the instrument. This study confirms that the model with the best fit is that consisting of three interrelated factors, following the same structure as that used in previous studies carried out on workers [27,29,36], with significant correlations among the SMVM-S dimensions and adequate indices of internal consistency. Study 2 confirms the mediational model proposed by Shirom [25] in an academic context and contributes to the identification of affective factors that explain the effects of PA on different results [19]. The level of total PA per week would imply higher levels of vigor in students, while vigor would positively influence academic results and SWL levels and negatively influence the deterioration of MH. With few exceptions [61], the PA-vigor positive relationship (mainly the physical aspect of vigor) has been verified in different studies [62–66]. Vigor in university students derived from performing PA is characterized by a combination of moderate amounts of arousal and pleasure [67,68], affective experiences that have also been associated with physical exercise [69]. In the same way, it has been possible to verify that the levels of vigor in students have an effect on their average grades—as an indicator of performance—on their MH—with a lower incidence of psychological problems—and on their SWL. These results contribute to understanding psychosocial mechanisms, specifically the experimentation of positive affect, by which PA

affects the well-being and cognitive performance of university students, thus responding to the need to verify the mediational role of constructs such as the vigor that is proposed in different heuristic and conceptual models [19,25].

Providing to health and education professionals an instrument such as the SMVM-S would help to better understand the role that PA has in reducing risks and improving the well-being of university students, who show a high rate of psychological disorders [70], and a decrease in AP compared with other educational stages [71] and whose age includes the adult population group with lower levels of SWL (18-25 years) [72]. In fact, if we consider that a high percentage of university students (40-70%) can be considered as physically inactive [73–76], then the potential for PA to generate positive effects through the levels of vigor experienced is greater [77].

The results obtained herein also help to clarify the role of an affective type of variable such as vigor in one stage, namely, the university, which entails important changes in different facets [65,66] for young people.

Limitations

The current study considered total PA, without differentiating between light, moderate or vigorous PA or the different effects that these activity levels could have on the results. To make this decision, we used as a base the potential benefits of PA, even when the minimum levels recommended by international organizations were not reached [1–3], and the positive effect of PA on AP, regardless of the type of PA [78]. However, we are aware that in future studies, the mediating role of vigor should be verified by taking into account the different levels of PA and other variables such as environmental aspects [79].

Using self-report measures for the assessment of PA could be considered another limitation. Although this instrument concurs with other objective forms of evaluation, such as accelerometry [45], it is recommended that in future studies, the relationships of the model with other types of measurement be verified.

Finally, all the data were collected in between exam periods, whereas difficulties in managing exercise are greater during examination periods [80]. Thus, future studies should include different temporal moments to determine whether exam periods or other stressful situations influence the relations shown in this study.

Conclusions

The analysis of the vigor approach [25] in the university context allows us to test one of the mechanisms proposed at the psychosocial level by Lubans et al. [19], whereby PA affects the AP, MH and SWL of students through the effect of PA on vigor. This study offers health and education professionals an instrument (i.e., the SMVM-S) to make progress in improving the MH, SWL and AP of university students through the promotion of PA.

Abbreviations

PA: Physical Activity; SMVM: Shirom-Melamed Vigor Measure; SMVM-S: Shirom-Melamed Vigor Measure for students; SWL: Satisfaction with life; MH: Mental health; AP: Academic performance.

Declarations

Authors' contributions: MPM and ELZ designed the research; MPM conducted the research; MPM, JJRB and DCD performed the statistical analyses; MPM, ELZ, and DCD wrote the manuscript and reviewed the paper. All the authors read and approved the final manuscript.

Ethics approval and consent to participate. All the procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the University of Jaén Ethics Committee (reference number: JUN.18/1. PRY and NOV.19/1.PRY). Active written consent was obtained from the participants.

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Availability of data and materials: The dataset generated and analyzed during the present study is available from the corresponding author upon reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Tables

Table 1. *Goodness of fit indices for the tested models.*

	χ^2 S-B ^a	df ^b	NNFI ^c	CFI ^d	SRMR ^e	RMSEA ^f	90% CI ^g of RMSEA	$\Delta \chi^2$ S-B ^h
Model 1	1239.58***	54	0.57	0.65	0.15	0.18	(0.17-0.19)	-
Model 2	300.81***	52	0.91	0.93	0.09	0.08	(0.07-0.09)	-
Model 3	275.64***	51	0.91	0.93	0.07	0.08	(0.07-0.09)	40.37***
Model 4	231.54***	50	0.93	0.95	0.07	0.07	(0.06-0.08)	33.94***
Model 5	604.61***	42	0.74	0.83	0.08	0.14	(0.13-0.15)	-

^aSatorra-Bentler chi square

^bDegrees of freedom

^cNon-normed fit index

^dComparative fit index

^eStandardized root mean square residual

^fRoot mean square error of approximation

^gConfidence interval

^hScaled Satorra-Bentler chi square difference

*** $p < 0.001$

Table 2. Standardized and unstandardized coefficients for CFA Model 4 and reliability indicators.

Items	B ^a	SE ^b	β^c	R ^{2d}	Factor	ρ^e	CR ^f	AVE ^g
SMVM-S 1	1.00	0.00	0.79	0.62	Physical strength	0.84	0.91	0.66
SMVM-S 2	1.15	0.05	0.84	0.71				
SMVM-S 3	1.09	0.05	0.81	0.65				
SMVM-S 4	1.04	0.05	0.80	0.64				
SMVM-S 5	1.01	0.05	0.79	0.62				
SMVM-S 6	1.00	0.00	0.61	0.37	Cognitive liveliness	0.76	0.83	0.62
SMVM-S 7	1.72	0.11	0.96	0.91				
SMVM-S 8	1.51	0.09	0.76	0.58	Emotional energy	0.75	0.81	0.52
SMVM-S 9	1.00	0.00	0.61	0.37				
SMVM-S 10	1.18	0.08	0.73	0.54				
SMVM-S 11	1.42	0.09	0.83	0.69				
SMVM-S 12	1.09	0.08	0.68	0.47				

^aUnstandardized coefficient

^bStandard error

^cStandardised coefficient

^dSquared multiple correlation

^eRaykov composite reliability for correlated errors

^fComposite reliability

^gAverage variance extracted

Note. All factor loads were significant.

Table 3. *Goodness of fit indices for the nonnested models.*

	χ^2 S-B	df	NNFI	CFI	SRMR	RMSEA	90% CI of RMSEA	CAIC ^e
Model 1 ^a	106.03***	59	0.89	0.92	0.05	0.05	(0.04-0.07)	-291.236
Model 2 ^b	108.82***	62	0.90	0.92	0.05	0.05	(0.03-0.06)	-308.643
Model 3 ^c	114.81***	60	0.87	0.91	0.06	0.05	(0.04-0.07)	-289.193
Model 4 ^d	278.63***	62	0.52	0.62	0.18	0.11	(0.09-0.12)	-138.838

^aSaturated model

^bNo direct effect

^cNo effect from predictor variable to the mediator

^dNo effect from the mediator to outcome

^eConsistent Akaike information criterion

*** $p < 0.001$

Figures

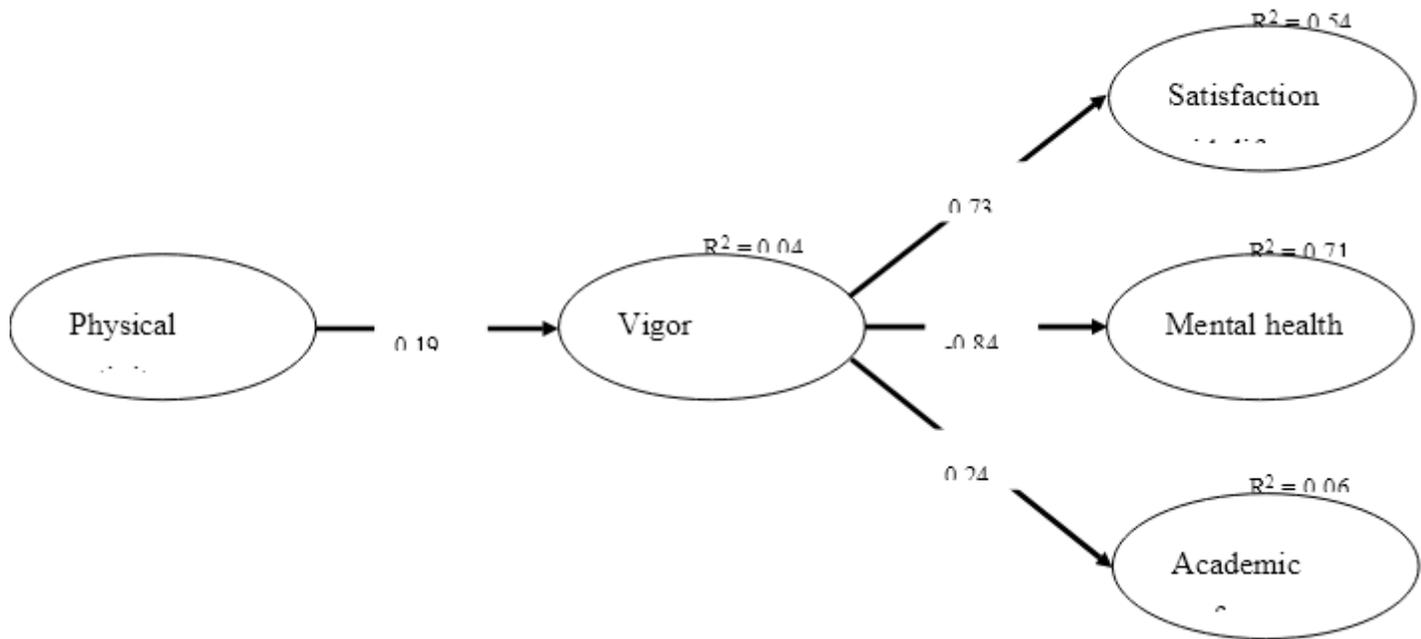


Figure 1

Estimated standardised regression and squared multiple regression (R²) coefficients for Model 2 (no direct effect). Note. All estimated standardised regression and squared multiple regression (R²)

coefficients were significant.