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Maturity Associated Variance in Physical Activity and Health-Related Quality of Life in Adolescent Females: A Mediated Effects Model

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Background: This study tested a mediated effects model of psychological and behavioral adaptation to puberty within the context of physical activity (PA). ***Methods:*** Biological maturity status, physical self-concept, PA, and health-related quality of life (HRQoL) were assessed in 222 female British year 7 to 9 pupils (mean age = 12.7 years, SD = .8). ***Results:*** Structural equation modeling using maximum likelihood estimation and bootstrapping procedures supported the hypothesized model. Maturation status was inversely related to perceptions of sport competence, body attractiveness, and physical condition; and indirectly and inversely related to physical self-worth, PA, and HRQoL. Examination of the bootstrap-generated bias-corrected confidence intervals representing the direct and indirect paths between suggested that physical self-concept partially mediated the relations between maturity status and PA, and maturity status and HRQoL. ***Conclusions:*** Evidence supports the contention that perceptions of the physical self partially mediate relations maturity, PA, and HRQoL in adolescent females.

Keywords: adolescence, exercise, physical self-concept

Physical activity (PA) plays an important role in the promotion and maintenance of health. Individuals who regularly engage in moderate-to-vigorous bouts of PA demonstrate improved functional capacity and are at less risk for many degenerative diseases and psychological disorders (eg, hypertension, type 2 diabetes, coronary heart disease, depression, and anxiety).[1] PA is also considered a prerequisite for positive physical and psychological development.[2] To ensure the health benefits afforded through regular involvement in PA, children should be encouraged to be active from an early age. However, evidence suggests that over the past 4 decades children are becoming less active in many forms of PA, including physical education, active transport, and leisure-time activities.[3]

Those involved in the study and promotion of PA in youth have generally focused on the roles that psychosocial and environmental factors play in relation to PA.[4] Although factors, such factors undoubtedly contribute to children's involvement in PA, it is increasingly evident that a true explanation of PA in youth resides in the independent and interactive effects of various biological, psychosocial, and environmental factors.[5,6] Accordingly, it has been suggested that researchers reexamine the biological basis of PA with the intention of informing both theory and practice.[5–8] PA is, after all, a biological process that exists within a complex cultural context in which value, meaning, and sanctions are ascribed to it.[8]

A number of biological factors and processes have been identified as potential contributors to variance in PA, including biological maturation.[6] Biological maturation refers to progression toward the mature (ie, adult) state, can be considered in terms of tempo and/or timing,[2] and may be particularly relevant to the study of PA in youth.[6] Tempo refers to the rate at which maturation progresses, whereas timing refers to the time at which certain maturity-related events occur (eg, age-at-menarche or peak height velocity). Children of the same chronological age can demonstrate considerable variation in biological maturity, with some maturing much earlier or later than others.

There is good reason to believe that variance in biological maturation may contribute to PA in adolescence, particularly in females. First, the observation that individuals become less active as they progress toward the mature state is a consistent finding in pediatric exercise science.[6] Second, evidence suggests that sex-related variance in biological maturation explains differences in the PA of boys and girls of the same chronological

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age.[9] Third, the physical characteristics associated with advanced maturation in girls (ie, greater pubertal gains in height, weight, and weight-for-height, with gains in weight a result of increases in absolute and proportional fat-mass) may be less conducive to successful involvement in PA,[7,8] especially in activities that emphasize endurance, weight-bearing, and/or aesthetics. Finally, girls who are advanced in maturity status are more likely to socialize with older, and less active, peer groups.[10]

In accordance with extant literature,[9] one would predict an inverse relation between maturity status and PA in this adolescent females. Research examining this contention has, however, produced equivocal results.[9] Whereas some studies have shown late maturing females to be more active than early maturing females,[11,12] others have found no relation between maturity status and PA,[13,14] or that early maturing girls were more active.[15] Lack of consistency in these findings has been attributed to a number of factors, including a failure to address factors that may moderate or mediate relations between maturation and PA, sample size, and construct measurement.[9] Whereas some studies have relied on subjective measures of PA and maturation, others have employed a combination of objective and subjective measures, or objective measures exclusively. For a more comprehensive review and discussion of research pertaining to maturity associated variance in PA see Sherar et al.[9]

In an attempt to explain relations between maturation status and PA in adolescent girls, Cumming and colleagues[16] proposed and tested a mediated effects model of maturity associated variance in PA. The model, based on a Mediated Effects Model of Psychological and Behavioral Adaptation to Puberty described by Petersen and Taylor,[17] hypothesized that relations between maturation status and PA were mediated by physical self-concept (ie, the feelings and beliefs that one has toward the physical self). More specifically, it predicted that maturity status would be inversely related with perceptions of physical self-concept, which would, in turn, positively predict involvement in PA. Structural equation modeling employing bootstrapping procedures indicated strong support for the model (CFI = .95; SRMR = .08) in a sample of adolescent British female students aged 12 to 15 years. Early maturing girls held lower perceptions of body attractiveness, sport competence, physical conditioning (but not strength) and overall physical self-worth, which, in turn, predicted less involvement in PA. An indirect inverse relation between maturation and PA was observed, through physical self-concept, supporting the contention that physical self-concept mediates relations between the aforementioned constructs.

Although the mediated effects model serves as a promising framework from which to study and understand maturity associated variance in PA, it has, to date, received limited empirical attention. Accordingly, the purpose of our investigation was to test the aforementioned model on a separate sample and extend it to include a measure of health-related quality of life (HRQoL) (Figure 1). There is good reason to believe that maturation may be related to HRQoL in adolescent females. Due to greater gains in absolute and proportional fat-mass, early maturing girls are more likely to be classified as overweight or obese. Overweight and obese youth tend to report lower levels of HRQoL when compared with their normal weight peers.[18–21] Early maturation also is associated with a more negative body image and physical self-concept[22] and less involvement in health promoting activities such as exercise[23] and competitive sports.[24] Early maturing girls also report more negative initial experiences to puberty (eg, inconvenience, ambivalence and confusion;[25] and increased distress, anxiety, depression, and psychosomatic symptoms.[22,26–28] Early maturity is also linked with early substance abuse,[29] alcohol abuse,[30] and early sexual initiation.[31]

In accordance with extant literature pertaining to maturation, PA and health in adolescent girls,[2,13,32] the hypothesized mediated effects model (Figure 1) predicted that (i) advanced maturation would predict lower perceptions of sport competence, body attractiveness, and physical condition, but higher perceptions of strength; (ii) that perceptions of sport competence, body attractiveness, physical condition, and strength would, in turn, positively predict physical self-worth; (iii) that physical self-worth would positively predict involvement in PA; (iv) that PA and would positively predict HRQoL; (v) that biological maturity status would indirectly predict variance in both physical self-worth, PA, and HRQoL; and (vi) and that physical self-worth would directly and indirectly (via PA) predict HRQoL.

Methods

Participants

Participants were 222 female Year 7 through 9 pupils from a single-sex state funded school in the South West of England (mean age = 12.7, SD = .8 years; range = 10–14 years). The study was approved by the School for Health's research ethics committee. Written consent was obtained from the Head Teacher, who acted in *loco parentis*. Parents were informed of the research by post and asked to provide passive consent (ie, contact the school/researchers if they did not wish their child to take part). Verbal consent was obtained from pupils.

Field Protocol

Before the start of a Physical Education class, participants completed a series of self-report questionnaires, including the Physical Activity Questionnaire for Adolescents (PAQ-A),[33] the Children and Youth's Physical Self-Perceptions Scale (CY-PSPP),[34] and the Kidscreen-10 HRQoL Questionnaire (K-10). Height and weight were measured using standardized procedures.[35] Chronological age in decimals was calculated as the difference between date of birth and date of measurement.

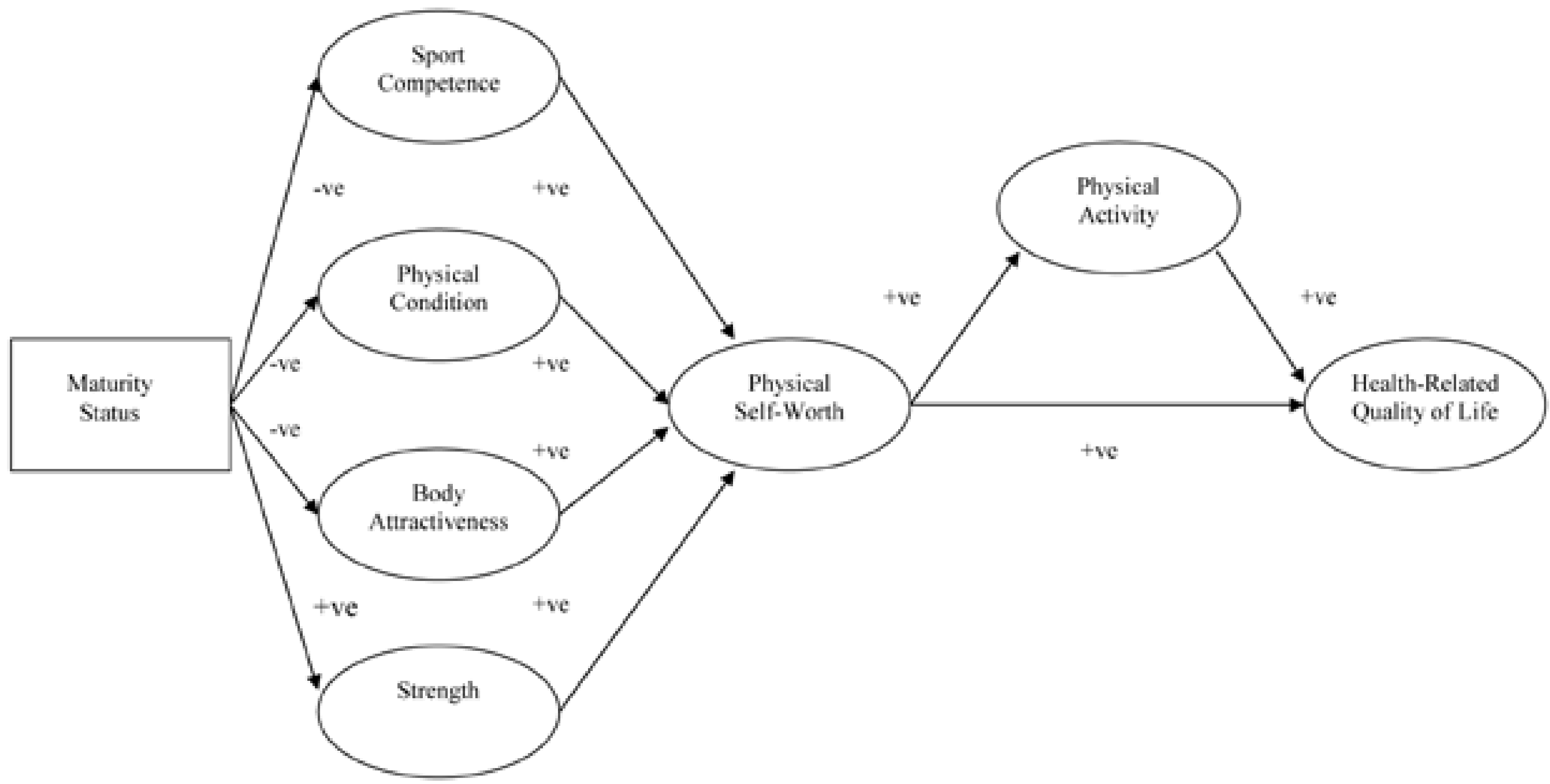

Figure 1 — Hypothesized mediated effects model describing relations among biological maturity status, physical self-concept, physical activity and health-related quality of life in adolescent females.

Measures

Estimated Maturity Status. Percentage of predicted mature (adult) height attained at the time of measurement was used as a noninvasive estimate of biological maturity status. This method assumes that among youth of the same chronological age, the child who is closer to his/her predicted mature height is biologically older (ie, more advanced in maturity) than the individual who is further removed from his/her predicted adult height than expected for age.[2] For example, the mean percentage of mature height attained in girls of the Berkeley Guidance Study at the age of 12 years is 93%.[36] A girl who has attained 98% of her predicted adult height at 12 years would be considered biologically older than a girl of the same chronological age who has attained 86% of her predicted adult height.

The Khamis-Roche method[37] was used to predict the mature height from current age, height and weight of the participant and midparent height (average height of biological parents). The median error bound (median absolute deviation) between actual and predicted mature height at 18 years of age is 2.2 cm in males and 1.7 cm in females.[37] Biological parents of the participants reported their heights. As adults generally overestimate height, the self-reported height of each parent was adjusted for over estimation using an equation constructed from over 1000 measured and estimated heights of adults.[38]

Estimated biological maturity status was expressed as a z-score, using the percentage of predicted adult height attained at the time of measurement, and half-year age- and sex-specific means and standard deviations from the Berkeley Guidance Study.[36] The reference sample was selected on 4 counts: first, mean heights and weights of boys and girls aged 13 to 15 years in the guidance sample are similar to current United Kingdom reference values;[39] second, means and standard deviations in the guidance sample are reported at half year intervals; third, the Khamis-Roche method for predicting adult height uses the same half-year age intervals as the Guidance study sample; fourth, the mean percentages of predicted adult height attained at all whole years (eg, 11.0 years, 12.0 years) are very similar to those in a more recent sample.[37] The Khamis-Roche method for estimating biological maturation has been used in a number of studies with US and British youth[40–43] and has been validated against established indicators of maturity (skeletal age) in youth American football players.[44]

Physical Activity. The Physical Activity Questionnaire for Adolescents (PAQ-A)[33] was used to assesses involvement in PA. The PAQ-A is an 8-item instrument that requires participants to indicate how frequently they engaged in various activities over a 7-day recall period. The PAQ-A has demonstrated adequate levels of validity and reliability.[45] In the current sample, the PAQ-A demonstrated an acceptable level of internal consistency (Cronbach's $\alpha = .79$).

Physical Self-Concept. The Children and Youths' Physical Self-Perception Profile (CY-PSPP)[34] was used to assess the physical self-concept. This scale assesses 6 dimensions of the self (ie, sport competence, physical condition, body attractiveness, strength, physical self-worth, and general self-worth) and requires participants to responds to a series of 36 items that are structured in an alternative response format Theoretically, the physical self-worth dimension is considered a higher-order construct, with sport competence, physical condition, body attractiveness, and strength serving as lower-order constructs that contribute to physical self-worth. All dimensions of the CY-PSPP, with the exception of general self-worth were included in the current analyses. The CY-PSPP has previously demonstrated acceptable levels of construct validity and reliability.[46] All dimensions of the CY-PSPP used in the current study demonstrated adequate levels of internal consistency (Cronbach's α ranged from .89 to .93).

Health-Related Quality of Life. HRQoL was assessed using the Kidscreen-10 HRQoL Questionnaire (K-10). The inventory contains 10 items comprising psychological, physical, and social dimensions of HRQoL. Based on a 1-week recall period, pupils estimated the intensity of their feelings toward each item using a 5-point Likert scale. Rasch scores were calculated, after the reversal of negatively formulated items, and converted into t-values with a scale mean of 50 and a standard deviation of 10, based on data from the Kidscreen international survey sample (The Kidscreen Group, 2006). Higher scores reflect superior HRQoL. Good test retest reliability ($r = .73$; ICC = 0.72) and high convergent validity with other generic HRQoL instruments, including the Youth Quality of Life Instrument-Surveillance Version ($r = .61$), was supported by The Kidscreen Group (2006). Acceptable internal consistency was exhibited in the current sample (Cronbach's $\alpha = .79$).

Statistical Analyses

Descriptive statistics by age group were calculated for body size, percentage of predicted mature height, maturity status, physical self-concept, PA, and HRQoL. Pearson product moment correlations (one-tailed) were calculated to examine relations among the variables of interest. Structural equation modeling, utilizing maximum likelihood estimation and bootstrapping procedures, was used to test the hypothesized model concerning relations among maturational status, physical self-concept, PA, and HRQoL. To determine the adequacy of model fit, a 2-index presentation strategy advanced by Hu and Bentler[47] was employed. This strategy uses the Standardized Root Mean Square Residual (SRMR) and incremental or absolute indexes of fit (eg, Comparative Fit Index -CFI). SRMR values close to .08 (or lower) are indicative of a well-specified model[47] whereas CFI values of over .90 and .95 reflect acceptable and excellent fit between the model and data, respectively.[47] In accordance with recent recommendations,[48] mediated effects were explored by examining the 90% upper and lower limits of bootstrap-generated bias-corrected confidence intervals (BBC CI) of indirect effects.

Results

Descriptive Statistics

Descriptive statistics for chronological age, body size, estimated maturity status, physical self-concept, PA, and HRQoL are summarized by age group in Table 1. Mean values for maturity status z-scores approximated, or fell just below, 0 in the 11-, 12-, and 13-year-old age groups and were lowest in the 14-year-old age group. Compared with UK reference values,[39] mean heights fell between the 50th and 75th centiles for age in each age group. Mean values for weight and BMI fell between the 50th and 75th centiles at age 12 and 14, yet approximated the 75th centile at 11 and 13 years. Mean values for BMI approximated or fell just below the 75th centile in all age groups. Mean values for HRQoL fell below the International Standard in all age groups.

Correlations

Relations between biological maturity status, physical self-concept, PA, and HRQoL are presented in Table 2. As predicted, estimated biological maturity status was negatively associated with sport competence, physical condition, body attractiveness, physical self-worth, PA, and HRQoL. Though positive, the relation between maturation status and strength was nonsignificant. PA was positively associated with HRQoL and all dimensions of the CY-PSPP.

The Mediated Effects Model

Given the complexity of the hypothesized model, a parceling strategy[49] was employed to limit the number of estimated parameters. The 6 items of each subscale of the CY-PSPP were parceled into 3 indicators of a latent variable that reflected the subscale. The 3 items with the highest item-to-construct loadings were used to anchor each of the 3 indicators. The 3 items with the next highest loadings were then added to the anchors in reverse order (eg, 1st & 6th, 2nd & 5th, and 3rd & 4th, highest loading items parceled together), thus increasing the likelihood that parcels were balanced in terms of difficulty and discrimination and limiting experimenter bias.[49] The sum of the 2 items was used to create each indicator of the latent variable (ie, parceled item). Using the same procedures, the 8 items representing the PAQ-A were parceled into 4 indicators of a latent variable that reflected PA. Similarly, the 10 items representing HRQoL were parceled into 5 indicators of a latent variable that represented that construct. For a more in-depth explanation of parceling process and its advantages see the review by Little and colleagues.[49]

In light of the moderate-to-strong correlations among the subdimensions of the CY-PSPP, covariance paths between the disturbance terms of the latent factors (ie, sport competence, physical condition, body attractiveness, strength) were added to the hypothesized model. These paths specify the interrelations between the various subdimensions and the shared variance not accounted for by the predictor variable.

Table 1 Descriptive Statistics for Chronological Age, Estimated Biological Maturity Status, Physical Self-Perceptions, and Physical Activity of Adolescent British Female Pupils by Age Group

	11 years* (n = 54)	12 years (n = 88)	13 years (n = 60)	14 years (n = 20)
Chronological age	11.59 (.2)	12.47 (.3)	13.39 (.3)	14.11 (.1)
Maturity status z-score	–.13 (.87)	–.29 (.92)	.07 (.87)	–.43 (.70)
Height (cm)	151.9 (7.5)	155.0 (6.6)	161.8 (6.2)	163.1 (6.3)
Weight (kg)	43.6 (8.5)	46.7 (8.6)	55.3 (9.6)	54.2 (6.5)
BMI (kg/m^2)	18.8 (2.6)	19.3 (2.8)	21.1 (3.2)	20.3 (1.9)
Sport competence	2.57 (.71)	2.65 (.61)	2.56 (.65)	2.64 (.74)
Physical condition	2.69 (.70)	2.87 (.58)	2.69 (.72)	2.81 (.77)
Body attractiveness	2.54 (.62)	2.54 (.69)	2.37 (.74)	2.47 (.65)
Physical strength	2.58 (.58)	2.58 (.51)	2.55 (.60)	2.38 (.48)
Physical self-worth	2.68 (.70)	2.72 (.67)	2.61 (.68)	2.62 (.73)
Physical activity	2.67 (.64)	2.54 (.56)	2.59 (.69)	2.71 (.66)
Health-related quality of life	47.0 (7.8)	45.5 (7.2)	46.0 (7.3)	44.9 (6.5)
Percentage of predicted adult stature attained	90.9 (2.9)	93.6 (2.7)	97.0 (1.9)	97.7 (.9)

* This subsample includes 1 child aged 10.93 years.

Table 2 Pearson Product Moment Correlations (One-Tailed) Between Measures of Estimated Biological Maturity Status, Physical Self-Concept, Physical Activity, and Health-Related Quality of Life

	1	2	3	4	5	6	7
1. Biological maturity status							
2. Sport competence	–.18**						
3. Physical condition	–.27***	.82***					
4. Body attractiveness	–.34***	.61***	.61***				
5. Physical strength	.10	.55***	.48***	.38***			
6. Physical self-worth	–.25***	.76***	.74***	.83***	.51***		
7. Physical activity	–.18**	.51***	.52***	.33***	.40***	.43***	
8. Health-related quality of life	–.12*	.43***	.38***	.42***	.26***	.52***	.21**

* $P < .05$; ** $P < .01$; *** $P < .001$.

Employing AMOS 16.0 software, structural equation modeling (SEM) using maximum likelihood estimation was used to test the fit of the hypothesized model. Inspection of the Mardia's Coefficient value (63.46, $P < .001$) revealed the data to depart from multivariate normality. Thus, the SEM analysis was conducted using the bootstrapping procedure with 5000 bootstrap replication samples to provide a more accurate assessment of the parameter estimates' stability.[50]

The model fit indices suggested a good fit between the proposed model and the data (SRMR = .07; CFI = .95).The standardized Beta coefficients, standard errors, and squared multiple correlations (SMC) associated with the model are presented in Figure 2. As predicted, biological maturity status negatively predicted perceptions of sport competence ($\beta = –.19$, $P < .01$), physical condition ($\beta = –.29$, $P < .001$), and body attractiveness ($\beta = –.35$, $P < .001$). Maturity status was, however, unrelated to perceived strength. Perceptions of sport competence ($\beta = .39$, $P < .01$) and body attractiveness ($\beta = .58$, $P < .001$), but not physical condition or strength, predicted physical self-worth. In turn, physical self-worth positively predicted involvement in PA ($\beta = .50$, $P < .001$) and HRQoL ($\beta = .67$, $P < .001$). Contrary to expectations, PA was unrelated to HRQoL. Finally, maturity status was found to be indirectly related to physical self-worth [$\beta = –.28$ (90% CI ± .11), $P < .001$], PA [$\beta = –.14$ (90% CI ± .08), $P < .001$], and HRQoL [$\beta = –.17$ (90% CI ± .08), $P < .001$]. An indirect relation between physical self-worth and HRQoL was not observed [$\beta = –.06$ (90% CI ± .12), $P > .05$].

A version of Baron and Kenny's method for testing meditational hypotheses[51] adapted for structural equation modeling[52] was employed to test for mediation in the indirect effects. Accordingly, bootstrap-generated bias-corrected confidence intervals were used to estimate the standardized path coefficients representing the direct effects, with and without the inclusion of the mediating variables. Without the mediating variables the direct path coefficients between maturity and physical self-worth [$\beta = –.26$ (BBC 90% CI = –.38, –.14), $P < .001$], and maturity and PA [$\beta = –.19$ (BBC 90% CI = –.33, –.06), $P < .01$], and maturity and HRQoL [$\beta = –.15$ (BBC 90% CI = –.30, .00), $P = .05$] were negative and significant. However, when the mediating variables were included in the model the path coefficients representing the direct effects between maturity and physical self-worth [$\beta = .04$ (BBC 90% CI = –.06, .14), $P = .39$], maturity and PA [$\beta = –.07$ (BBC 90% CI = –.15, .07), $P = .32$], and maturity and HRQoL [$\beta = .00$ (BBC 90% CI = –.15, .15), $P = .99$] were all attenuated and nonsignificant. Collectively, these results suggest that the indirect effect between maturity and physical HRQoL was fully mediated, and that the indirect effects between maturity and physical self-worth, and maturity and PA were partially mediated.[I] Inspection of the modification indices and standardized residuals associated with the hypothesized models did not indicative any improvements to the model that were theoretically or substantively justified.

Discussion

The results of this study provide partial support for the hypothesized mediated effects model and the contention that advanced maturation in adolescent girls is associated with less involvement in PA.[11,12] Specifically, physical self-concept was found to partially mediate an inverse relation between maturity status and PA. The magnitude and direction of the path coefficients in the hypothesized model were consistent with those described in the mediated effects model presented by Cumming and colleagues.[16] Advanced maturation was associated with lower perceptions of body attractiveness, physical condition and sport competence, though no relation was observed with perceived strength. Perceptions of body attractiveness and sport competence, but not strength or physical condition, served as positive predictors of

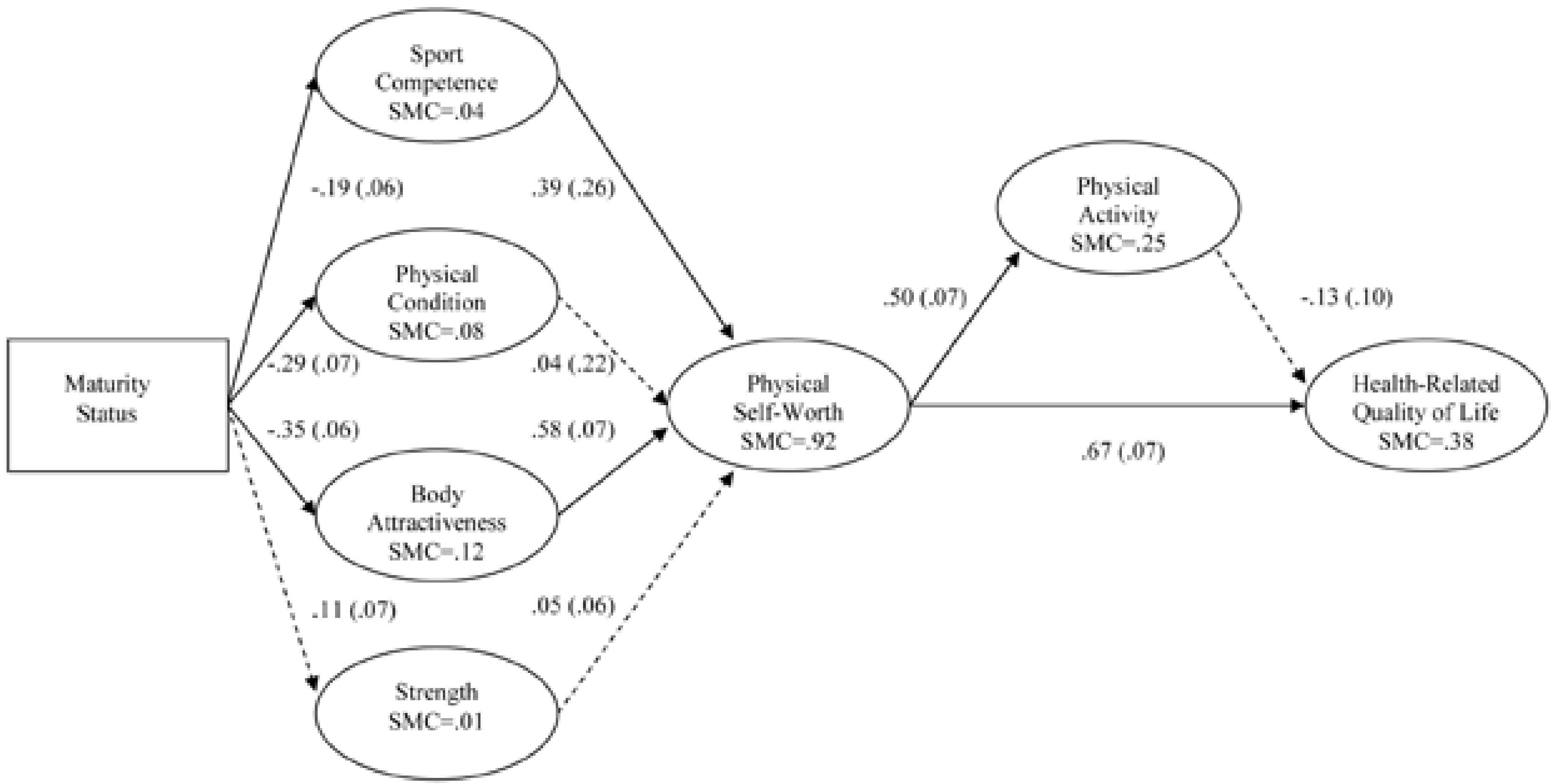

Figure 2 — Mediated effects model describing relations among biological maturity status, physical self-concept, physical activity and health related quality of life in adolescent females. *Note.* All solid line parameters are significant ($P < .05$). Dashed line parameters are nonsignificant. Standardized Beta coefficients are presented by each parameter with standard errors in parentheses. Indirect effects were observed between maturity status and physical self-worth [$\beta = -.28$ (BBC 90% CI = –.39, –.17), $P < .001$], maturity status and physical activity [$\beta = -.14$ (BBC 90% CI = –.22, –.08), $P < .001$], and maturity status and health related quality of life [$\beta = -.17$ (BBC 90% CI = –.25, –.10), $P < .001$]. Factors indicators are not included in the model for the purpose of making the presentation less complex. Correlations between the errors associated with the 4 subdimensions of the physical self were all significant and were as follows; sport competence & physical condition $r = .92$; sport competence & body attractiveness $r = .67$; sport competence & strength $r = .66$; physical condition & body attractiveness $r = .63$; physical condition & strength $r = .60$; body attractiveness & strength $r = .49$.

physical self-worth which, in turn, predicted greater involvement in PA.

The current model advanced the original model[16] by including HRQoL as endogenous latent variable. As predicted, HRQoL was found to be positively related physical self-worth and indirectly and inversely related to maturity status. Physical self-concept and PA were found to fully mediate the inverse relation between maturation status and HRQoL, further highlighting the potential role that perceptions of the self and PA may play in explaining relations between maturation status and HRQoL in adolescent females. Future research should explore the independent and interactive effects of maturation, physical self-concept, and PA in relation to a wider range of health outcomes (eg, smoking, drinking, diet, sexual behavior). Contrary to expectations, PA was found to be unrelated to HRQoL. This result was somewhat surprising, as previous research has reported positive relations between these constructs.[53]

The comparatively strong relations among maturation, body attractiveness, and physical self-worth are worthy of discussion. Maturity-associated changes in physical appearance (eg, body size, composition, physique, development of secondary sex characteristics) may be of greater importance to adolescent females than changes in functional capacity (eg, sport competence, physical condition, strength).[9] Physical appearance is recognized as the most salient source of self-worth and esteem in adolescent girls.[54] A qualitative study of over 50 US adolescent girls and boys revealed that the subject of body attractiveness dominated girls conversations during adolescence and was considered to be of greater importance than accomplishments in achievement domains such as education and sports.[55] Strength and physical condition may also be less salient as sources of self-worth among adolescent females than they are in males.[56]

The mediated effects model described by Petersen and Taylor[17] presents an appealing multidisciplinary framework through which maturity-associated variation in health related behaviors can be studied. The model also affords an ideal framework from which to examine the potential influence of social and environmental factors. For example, the degree to which maturation and physical self-concept impact involvement in PA, might be moderated by social support (eg, peer or parental), cultural ideals, or the availability of activity related resources (ie, parks, leisure centers). Although the impact of moderating factors was not examined in the current study, future researchers should seek to explore and validate this aspect of Petersen and Taylor's model.[17]

From a practical perspective, Petersen and Taylor's[17] model identifies a means through which maturity associated declines in PA and HRQoL might be countered (ie, physical self-concept, social support). A lack of subjective and cognitive knowledge with regards to the female body and the processes of growth and maturation has been documented as a source of anxiety in adolescent girls.[55] Interventions designed to educate students on the processes of growth and maturation, and/or encourage them to view puberty as a normal and attractive consequence of becoming an adult, may help students adapt more positively to pubertal changes in health and behavior. Such interventions would undoubtedly require a combination of education and the personal reorganization and reinterpretation of body image and related self-concepts, and might mirror or develop from existing interventions such as Cash's body-image Cognitive Behavioral Therapy (CBT) program.[57] Although there is much evidence that body-image CBT programs are effective in collegiate and adult samples, there is a paucity of literature examining the efficacy of such interventions in adolescents.[58] Most interventions seeking to promote positive change in adolescents' physical self-concept have limited their strategies to the promotion of exercise (Fox, 2000). Though greater involvement in exercise can undoubtedly enhance physical self-concept, such interventions are limited in that they do not challenge the beliefs and perceptions that underpin physical self-concept.

It is important to recognize a number of limitations associated with the current study. First, the results are limited to adolescent girls living in the Southwest of England. Relations among the variables of interest might vary with age, social circumstance, and culture. For example, body attractiveness is considered a more salient source of self-worth in working class girls,[55] and African American girls tend to be more satisfied with their bodies than white girls.[59] Second, inferences regarding cause and effect relations cannot be made due to the study's cross-sectional design. To obtain more precise information about how physical self-perceptions might mediate relations between maturation and PA it, longitudinal research is required, ideally beginning in late childhood and tracking changes through to late adolescence. Third, the method for estimating maturity status was derived from data collected in the United States. British and American boys and girls aged 9 to 15 years present very similar mean heights and weights[60] (http://www.cdc.gov/growthcharts), however, further research is required to validate the formulae in British samples. Although mean estimates of maturity status were generally 'on-time,' the mean values suggested a slight delay in maturity status in the oldest age group. This may reflect the relatively smaller group sizes or a tendency for older early maturing girls to opt out of studies that require measurements of weight. Finally, self-report measures of PA rely on the participant's memory to assess activity levels and can potentially be influenced by socially desirability. Despite these limitations, the PAQ-A is considered a valid, low cost, and easy to use measures of activity that is well suited for use within youth.[33,45]

In summary, this study supports the mediated effects of model of maturity associated variation in PA[16] and the contentions that advanced maturation in adolescent females is associated with less involvement and PA and lower HRQoL. Accordingly, researchers PA and HRQoL in youth would do well to consider the contribution of biological maturity status and its potential role as a confounding and/or masking variable.[61]

Notes

[I] At the request of a reviewer, a model specifying direct paths from a potential covariate (viz., chronological age) was analyzed to examine any potential effects of this variable on the paths shown in Figure 2. The direct and indirect path coefficients remained significant, indicating that they did not differ as a function of chronological age.

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