The Mediating Role of Physical Self-Concept on Relations between Biological Maturity Status and Physical Activity in Adolescent Females

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Abstract

The current study examined the mediating role of physical self-concept on relations between biological maturity status and self-reported physical activity in adolescent British females. Biological maturity status, physical self-concept and physical activity were assessed in 407 female British year 7-9 pupils (M age = 13.2 years, SD = 1.0). Participants completed the Physical Activity Questionnaire for Adolescents (Kowalski, Crocker, & Donen, 2004) and the Children and Youth Physical Self-Perceptions Profile (Whitehead, 1995). Percentage of predicted adult height attained at measurement was used as an estimate of biological maturity status. Structural equation modeling using maximum likelihood estimation and boot-strapping procedures revealed that perceptions of sports competence, body attractiveness and physical self-worth mediated an inverse relation between maturity status and physical activity. The results provide partial support for Petersen and Taylor's (1980) Mediated Effects Model of Psychological and Behavioural Adaptation to Puberty within the context of physical activity.

Key Words. Growth, maturity, girls, puberty, physical activity.

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The physical and psychological health benefits associated with regular involvement in moderate to vigorous bouts of physical activity are well documented. Indeed, individuals who are regularly active demonstrate improved functional capacity and are at a reduced risk for several degenerative diseases and psychological disorders, including coronary heart disease, hypertension, type II diabetes depression, and anxiety (Department of Health Physical Activity Health Improvement and Prevention, 2004). To accrue and optimize these benefits, however, regular involvement in physical activity should be encouraged from an early age. This withstanding, evidence gained over the past 40 years suggests that youth have become increasingly less active in many different contexts, including active transport (e.g., walking or cycling to school), physical education, and leisure-time exercise activities (Malina & Katzmarzyk, 2006).

In attempts to understand and promote physical activity in youth, researchers and practitioners have focussed predominantly on psychosocial and environmental factors such as motivation, social support, socio-economic status, and the built environment. Although there is little doubt that such factors contribute to individual differences in physical activity; a true explanation of children's involvement in physical activity resides in the independent and interactive effects of various biological, psychosocial and environmental factors. This philosophy, termed 'a biocultural perspective' (Malina, 2008), extends beyond the social and psychological domains, recognizing the importance of biological factors. Physical activity is, after all, a biological process that exists within a complex cultural context in which various values, meanings, and sanctions are ascribed to it. Consistent with a biocultural perspective, the International Association for the Study of Physical Activity and Obesity Task Force (Katzmarzyk, et al., 2008) recently recommended that researchers consider the independent and interactive effects of biological determinants upon physical activity and obesity in youth, with the goal of informing both theory and practice.

Researchers studying physical activity and health in youth would do well to consider the independent and interactive effects of biological growth and maturation. Growth refers to changes in body size, composition, proportions and physique (Malina, 2002), whereas maturation refers to progression towards the mature state (Malina, Bouchard, & Bar-Or, 2004).

Maturation status (i.e., the extent to which an individual is advanced, on time, or delayed in maturation) might impact involvement in physical activity, particularly during adolescence when maturity-associated variation in size, proportions, body-composition, and functional capacity (e.g., speed, strength, stamina) is greatest (Baxter-Jones, Eisenmann, & Sherar, 2005; Cumming, Standage, Gillison, & Malina, 2008). In males, advanced maturation is associated with greater gains in height, weight, weight-for-height and lean mass, resulting in a physique that is better suited for success in many forms of physical activity, particularly those that emphasise speed, power, and strength (Malina, et al., 2004). Advanced maturation in girls is also associated with greater gains in height, weight, and weight-for-height. However, gains in weight include a major fat component and physique changes that may be less appropriate for successful engagement in physical activity, especially those that involve weight bearing, endurance, or an aesthetic component, such as distance running or gymnastics (Malina, et al., 2004).

The extant literature examining relations between biological maturity status and physical activity during adolescence, though limited and equivocal, suggests that advanced maturation is associated with less involvement in physical activity among girls, and marginally greater involvement in physical activity among males. For instance, in a sample of 5595 British 11 year olds an inverse relation between pubertal status and physical activity was noted in girls but not boys (Riddoch, et al., 2007). Moreover, advanced maturation in US females at 11 years has also been shown to be associated with less involvement in moderate-to-vigorous forms of physical activity at age 13 years (Baker, Birch, Trost, & Davison, 2007; Davison, Werder, Trost, Baker, & Birch, 2007). In contrast, a weak positive association has been observed between maturity status and moderate-to-vigorous physical activity in 7th grade US boys and girls (van Jaarsveld, Fidler, Simon, & Wardle, 2007), and studies of Scottish girls aged 11-13 years (Niven, Fawkner, Knowles, & Stephenson, 2007), US boys and girls 13-14 years (Wickel & Eisenmann, 2007), and Canadian girls aged 8-16 years (Sherar, et al., 2009) have failed to demonstrate associations between maturity status and physical activity. It should be noted that these studies have employed a variety of measures of biological maturation and physical activity and thus may not be directly comparable. Although indicators of sexual, skeletal, somatic, and hormonal maturation are positively related with one-another (Malina, et al., 2004), it is possible that physical activityvaries with different indices of maturation (Sherar, Cumming, Eisenmann, Baxter-Jones, & Malina, in press). For example, the initial appearance of secondary sex characteristics in girls may be more closely related to disengagement from physical activity than age at peak height velocity and/or menarche, both of which are late events in puberty.

The ‘Mediated Effects Model of Psychological and Behavioural Adaptation to Puberty’ (Petersen & Taylor, 1980) affords an appropriate conceptual framework from which to examine relations between biological maturation and physical activity in youth. The model holds that the effects of maturation on psychological and behavioural development are mediated by psychological variables and moderated by exogenous or contextual factors. Applied to the context of physical activity, psychological variables such as beliefs and attitudes pertaining to physical activity or the self are predicted to mediate the relation between maturity status and physical activity. Moderating factors include variables external to the person, such as cultural ideals, social agents or the environment.

Physical self-concept has been advanced as a potential mediator of relations between maturity status and physical activity (Malina, 2008; Monsma, Malina, & Feltz, 2006). This construct represents a person’s perceptions of the self as formed through experience with and interpretations of his or her environment related to the physical domain (Shavelson, Hubner, & Stanton, 1976). Physical self-concept is considered to be a determinant and outcome of physical activity (Weiss & Chaumeton, 1992), with positive self-concept predicting greater involvement in moderate-to-vigorous forms of physical activity, and physical activity begetting more positive self-concept (Sabiston & Crocker, 2008). Evidence linking physical self-concept to maturity status is, however, limited, inconsistent, and restricted to females. Employing the Children and Youth Physical Self Perceptions Profile (CY-PSPP;(Whitehead, 1995), past work has found advanced maturation to be associated with lower perceptions of the physical self-worth (Davison, et al., 2007; Niven, et al., 2007), body attractiveness (Niven, et al., 2007), and to a lesser extent sport competence (Craft, Pfeiffer, & Pivarnik, 2003).

Although researchers have examined relations among maturation, physical self-concept and physical activity, to date, no research has examined the potential mediating role of physical self-concept on relations between maturation and physical activity. Thus, the purpose of this study was to test a mediated effects model (cf (MacKinnon, Lockwood, & Williams, 2004)) (Figure 1) describing the mediating role of physical self-concept on relations between maturity status and physical activity in adolescent girls. In accordance with the Mediated Effects Model of Psychological and Behavioral Adaptation to Puberty (Petersen & Taylor, 1980) and extant literature pertaining to the biological and psycho-behavioral correlates of growth and maturation (Davison, et al., 2007; Malina, et al., 2004; Niven, et al., 2007), the model hypothesized that (i) advanced maturation in girls 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 physical activity; and (iv) that biological maturity status would indirectly predict variance in both physical self-worth and physical activity.

Method

Participants

Participants were 407 female Year 7 through 9 pupils from three state schools in the South West of England (*M* age = 13.2, *SD* = 1.0 years; range = 11-15 years).

Students in years 7-9 were chosen as this represents a time period where maturity associated variance in physical and functional characteristics is at its greatest in females (Malina, et al., 2004). State schools were chosen so as to provide a more representative sample of adolescent females in this region. The majority of the students were white (69.8%), with smaller proportions of Asian (17.0%), Black (2.0%), and Chinese (2.5%) students, and students of mixed ethnicity (8.8%). The study was approved by the University's School for Health research ethics committee. Written consent was obtained from the Head Teachers who acted in *loco parentis*. Parents were informed of the research by post and asked to provide passive consent (i.e., contact the school/researchers if they *did not* wish their child to take part). Verbal consent was obtained from pupils. Pupils who opted out of the study, were unable to provide self-reported height of both biological parents, did not wish to be weighed or measured, or did not fully complete the questionnaires were excluded from the sample. Taking these factors into account, the student participation rate was 55%.

Field Protocol

Prior to the start of a physical education class, participants completed a series of self-report questionnaires, including the Physical Activity Questionnaire for Adolescents (PAQ-A; (Kowalski, Crocker, & Donen, 2004) and the Children and Youth's Physical Self-Perceptions Scale (CY-PSPP; (Whitehead, 1995). Height and weight were measured using standardized procedures (Malina, 1995). Inter- and intra- observer technical errors of measurement for height were 0.26 cm and 0.23 cm, respectively (conducted on a separate sample). Replicate measurements of body weight, using a portable electronic scale (Omega 783 Seca Ltd.), showed negligible variation between trials (technical error of measurement for weight was 0.06 kg.). The body mass index (BMI, kg/m^2) was calculated. Chronological age in decimals was calculated as the difference between date of birth and date of measurement.

Measures

Estimated Maturity Status. Percentage of predicted mature (adult) height attained at the time measurement was used as a non-invasive estimate of biological maturity status. This method assumes that among youth of the same chronological age, the individual who is closer to his/her predicted mature height is biologically older (i.e., more advanced in maturity) than the individual who is further removed from his/her predicted adult height than expected for age (Malina, et al., 2004). For example, the mean percentage of mature height attained in girls of the Berkeley Guidance Study at the age of 12 years is 93% (Bayer & Bayley, 1959). 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 (Khamis & Roche, 1994) 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 (Khamis & Roche, 1994). Biological parents of the pupils reported their heights. As adults tend to overestimate height (Epstein, Valoski, Kalarchian, & McCurley, 1995), 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 (Epstein, et al., 1995).

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-yearly age- and sex-specific means and standard deviations from the Berkeley Guidance Study (Bayer & Bayley, 1959). This reference sample was selected for four reasons: first, mean heights and weights of boys and girls aged 13-15 years in the guidance sample are similar to current United Kingdom reference values (Freeman, et al., 1995); 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 (e.g., 11.0 years, 12.0 years) are very similar to those in a more recent sample (Khamis & Roche, 1994).

Physical Activity. The Physical Activity Questionnaire for Adolescents (PAQ-A; (Kowalski, et al., 2004) is an eight item instrument that requires participants to indicate how frequently they engaged in various activities over a seven day recall period. The PAQ-A has demonstrated adequate levels of validity and reliability (Kowalski, Crocker, & Kowalski, 1997). In the current sample the PAQ-A also demonstrated an acceptable level of internal consistency (Cronbach's alpha = .81).

Physical Self-Concept. The Children and Youths' Physical Self-Perception Profile (CY-PSPP; (Whitehead, 1995) was used to assess the participants' physical self-concept. This scale assesses 6 dimensions of the self (i.e., sport competence, physical condition, body attractiveness, strength, physical self-worth, and general self-worth) and requires participants to respond to a series of 36 items (6 items per subscale) that are structured in an alternative response format. Conceptually, the physical self-worth dimension is considered a higher-order factor, with sport competence, physical condition, body attractiveness, and strength serving as lower-order facets that contribute to one's physical self-worth. The CY-PSPP has demonstrated acceptable levels of construct validity and reliability in prior research (Eklund, Whitehead, & Welk, 1997). All of the dimensions, with the exception of general self-worth, were included in the current analyses and each demonstrated adequate levels of internal consistency (Cronbach's alpha: sport competence = .84; physical condition = .87; body attractiveness = .91; strength = .87; physical self-worth = .87). Confirmatory factor analysis revealed that the CY-PSPP demonstrated good model fit (CFI = .91; SRMR =.06). For a more comprehensive description of the CY-PSPP and its psychometric properties, please see Eklund and colleagues (Eklund, et al., 1997).

Statistical Analyses

Descriptive statistics by age group were calculated for body size, percentage of predicted mature height, and maturity status. Pearson product-moment correlations (one-tailed) were calculated to examine relations among maturation status, physical self-concept, and physical activity. Structural equation modeling, utilizing maximum likelihood estimation and bootstrapping procedures, was used to test the hypothesized mediated effects model. To assess the adequacy of model fit, a 2-index presentation strategy proposed by Hu and Bentler (Hu & Bentler, 1999) was used. This approach advances the use of the Standardized Root Mean Square Residual (SRMR) coupled with more incremental or absolute indices of fit, such as the Comparative Fit Index (CFI). Model fit values close to .08 (or lower) for the SRMR are indicative of a well-specified model (Hu & Bentler, 1999). For the CFI, values of over .90 and .95 are indicative of an *acceptable* and *excellent* fit, respectively (i.e., between the hypothesized model and study data) (Hu & Bentler, 1999). Akin with recent recommendations (MacKinnon, et al., 2004), the mediating role of physical self-concept was explored by examining the 90% upper and lower limits of bootstrap-generated bias-corrected confidence intervals (CI) of the indirect (or mediated) effects.

Results

Descriptive Statistics

Descriptive statistics for chronological age, body size, estimated maturity status, physical self-concept and physical activity 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 but were slightly negative in the 14 and 15 year old age groups. Compared to UK reference values (Freeman, et al., 1995), mean heights approximated the 50^{th} centile for age in each age group. Mean values for weight and BMI fell between the 50^{th} and 75^{th} centiles at 11, 12, 13 and 14 years and approximated the median at 15 years.

Correlations

Relations between biological maturity status, physical self-concept and physical activity are presented in Table 2. As predicted, estimated biological maturity status was negatively associated with sport competence, physical condition, body attractiveness, physical self-worth and physical activity, and positively associated with strength. Physical activity was positively associated with all five dimensions of the CY-PSPP; the magnitude of correlations varied from low to moderate.

The Mediated Effects Model

Given the complexity of the hypothesized model, an item parceling strategy was employed (Little, Cunningham, Shahar, & Widaman, 2002). There are a number of advantages associated with the strategy of parceling items, particularly when dealing with complex models and/or relatively small samples. These advantages include the creation of more parsimonious models that require fewer parameter estimates at local (i.e., construct definition) and global (i.e., model representation) levels, a greater item-to-sample ratio, increased reliability, a greater ratio of common to unique factor variance, a reduced likelihood for residuals to be correlated or dual loadings to emerge, and reductions in various sources of sampling error (Little, et al., 2002).

The six items representing each subscale of the CY-PSPP were parceled into three indicators of a latent variable that reflected that subscale. The three items with the highest loadings were used to anchor each of the three indicators. Subsequently, the three items with the next highest item-to-construct loadings were added to the anchors in reverse order (e.g., 1st and 6th highest loading items parcelled together), increasing the likelihood that parcels would be balanced in terms of difficulty and discrimination and eliminating experimenter bias (Little, et al., 2002). All parcels were created by calculating the sum of the two items. Using the same procedures, the eight items representing the PAQ-A were parceled into four indicators of a latent variable that reflected physical activity.

Given the moderate-to-strong relations among the various sub-dimensions of the CY-PSPP (see Table 2), covariance paths between the disturbance terms of the latent factors representing the sub-dimensions of physical self-worth (i.e., sport competence, physical condition, body attractiveness, strength) were added to the hypothesized model. These paths specify the interrelations between the four sub-dimensions and the shared variance that is not accounted for by the predictor variable. Though BMI has been linked with both maturity status and physical activity (Eisenmann & Wickel, 2009), it was not included in the model as its value is derived from data that is also used to estimate maturity status (i.e., participant height and weight). The inclusion of two or more highly correlated explanatory variables within a regression model can result in high levels of collinearity, increasing the error associated with related parameter estimates and the likelihood of an overfitted model.

Employing the AMOS 7.0 software, structural equation modelling using maximum likelihood estimation was used to test the fit to the data of the hypothesized model. Inspection of the Mardia's Coefficient value (6.98, $p < .001$) revealed the data to depart from multivariate normality. Thus, SEM analyses were conducted using the bootstrapping procedure with 5000 bootstrap replication samples to more accurately assess the stability of parameter estimates (Byrne, 2001).

The model fit indices suggested a good fit between the proposed model and the data (CFI =.95; SRMR = .07). As predicted, biological maturity status negatively predicted perceptions of sport competence (β=-.12, p<.05), physical condition (β=-.24, p<.001) and body attractiveness (β=-.30, p<.001), and served as a positive predictor of perceived strength (β=.21, p<.001). In turn, sport competence (β=.29, p<.001) and body attractiveness (β=.68, p<.001), but not physical condition (β=.10, p=.06) or strength (β=.07, p=.07), served as positive and significant predictors of physical self-worth. Finally, physical self-worth, positively predicted involvement in physical activity (β=.44, p<.001). In support of the hypothesized mediated effects model, significant indirect effects were observed between maturity status and physical self-worth (β = -.25 (BBC

90% CI = -.34, -.16), $p<.001$), and maturity status and physical activity (β = -.11 (BBC 90% CI = -.16, -.07), $p<.001$).

Examination of the modification indices suggested the inclusion of a direct path between physical condition and physical activity. However, as it was not possible to discern whether this path reflected a direct effect of conditioning on physical activity involvement or the conditioning effects associated with regular involvement in physical activity, it was not added to the model. To produce a more parsimonious, yet equally well fitting, model, non-significant pathways were considered for sequential deletion. Deletion of the pathway between strength and physical-self worth resulted in a non significant change in model fit ($\Delta\chi^2(1) = 3.30$, $p>.05$; ΔCFI =.00). Deletion of the pathway between physical condition and physical-self worth also resulted in a non-significant change in model fit ($\Delta\chi^2(1) = 2.06$, $p>.05$; ΔCFI =.00). The revised model (Figure 2) also demonstrated a good fit to the study data (CFI =.95; SRMR = .08).

An adaptation of the Baron and Kenny's method for testing meditational hypotheses (Baron & Kenny, 1986), using structural equation modelling and bootstrap-generated bias-corrected confidence intervals (Shrout & Bolger, 2002), was employed to test for mediation effects. Using this strategy, the standardized path coefficients representing the direct effects, with and without the inclusion of the mediating variables, are compared. Without the mediating variables the direct path coefficients between maturity and physical self-worth (β = -.24 (BBC 90% CI = -.33, -.16), $p<.001$), and maturity and physical activity (β = -.15 (BBC 90% CI = -.25, -.04), $p<.01$) were negative and significant. However, when the mediating variables were included in the model the path coefficients representing the direct effects between maturity status and physical self-

(β = .01 (BBC 90% CI = -.04, .07), p=.57) and maturity status and physical activity (β = -.05 (BBC 90% CI = -.15, .07), p=.43) were attenuated and non-significant. Collectively, these results suggest that the indirect effect between maturity status and physical self-worth was close to being fully mediated (95% portion of the total effect) by variance in perceived attractiveness and sport competence, and that the indirect effect between maturity status and physical activity was at least partially mediated (68% portion of the total effect) by variance in physical self-concept. [1]

Discussion

The results of this study support the contention that advanced maturation in adolescent girls is associated with less involvement in physical activity (Davison, et al., 2007; Riddoch, et al., 2007) and provide partial support for the Mediated Effects Model of Psychological and Behavioral Adaptation to Puberty (Petersen & Taylor, 1980) in the context of physical activity. More specifically, an indirect relation was observed between maturity status and physical activity, through physical self-concept. As predicted, girls who were advanced in maturity status perceived themselves as less attractive, less competent in sport, and less conditioned, yet physically stronger. In turn, perceptions of attractiveness and sport competence, but not strength or physical condition, predicted more positive self-worth which, in sequence, predicted greater involvement in physical activity.

The Mediated Effects Model described in the current study holds promise for those involved in the study and promotion of physical activity in youth. From a

[1] At the request of an anonymous 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.

theoretical perspective, it identifies a series of mechanisms (i.e., physical self concept) through which variance in biological maturation impacts adolescent girls' involvement in physical activity. It should also be recognized that involvement in physical activity can also enhance physical self-concept, thus the relation between these constructs can be thought of as bidirectional (Crocker, Sabiston, Kowalski, McDonough, & Kowalski, 2006). The comparatively stronger relations among body attractiveness, maturity status, and physical self-worth are to be expected. Maturity associated changes in physical appearance (e.g., body size, composition, physique, development of secondary sex characteristics) are more outwardly visible than changes in functional competence (e.g., sport competence, physical condition, and strength) and, thus, may serve as a more salient source of self-worth and esteem for adolescent girls (Page & Fox, 1997). Indeed, 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 (Martin, 1996). Strength and physical condition may also be less salient among adolescent females than it is in males (Cover-Jones, 1958).

From a practical perspective, this study identifies a potential mechanism (i.e. physical self-concept) through which reductions in physical activity among girls who are advanced in their maturity status may be countered. Variance in physical self-concept may explain why certain advanced-maturing girls (i.e., those with a positive physical self-concept) remain active during adolescence, whereas others (i.e., those with a negative physical self-concept) become less active. If girls who are advanced in maturity status can be encouraged to view the physical changes associated with puberty as a normal and attractive part of maturational process and not as a barrier to physical activity then they may be more likely to remain active. 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 (Martin, 1996). Likewise, if parents, educators, and peers are informed on the nature of the maturation process and its potential impact on health-related behaviors then they may provide a social climate that is more sensitive to the experiences of early-maturing girls, whilst simultaneously providing more active opportunities (i.e., activities better suited to advanced-maturing girls) and support.

Although the results of this study suggest that physical self-concept plays a role in explaining maturity-associated variance in physical activity, it is likely that a combination of biological, psychosocial and environmental factors contribute to adolescent's involvement in physical activity. For example, an early-maturing girl with positive feelings of physical self-worth, might still be discouraged from being active if she engages in activities that emphasise endurance or leanness over technical ability (e.g., cross-country) and/or experiences social or cultural pressures to avoid being active. Future research needs to identify and understanding additional factors that may contribute to maturity associated variance in physical activity, such as the physical demands of various activities, social support, and cultural ideals

The present study has several limitations that should be noted. First, the results are limited to adolescent girls living in the Southwest of England. Relations among maturation, physical self-concept, and activity might vary culturally and socially. In the United States, for example, African American girls are more satisfied with their bodies than American White girls (Parker, et al., 1995). Body attractiveness is also considered to be of greater value in working class girls (Martin, 1996). Second, the current study used a cross-sectional design. Thus, direct inferences regarding cause and effect relations cannot be made. Longitudinal research is required to obtain more precise information about how physical self-perceptions might mediate relations between maturation and physical activity, ideally beginning in late childhood and tracking changes through to late adolescence. Third, it is important to recognize that the participation rate (55%) in the current sample was relatively low. Examination of the mean Maturity z-sores by age group (Table 1) suggests that girls who were advanced in maturity status have been slightl less likely to have been represented in the current sample (i.e., if one expects a mean maturity z-score of 0.0), particularly in the two oldest age groups. However, as it was not possible to estimate the maturity status for non-participants, this remains speculation. Future studies should seek to examine factors that may discourage adolescent girls from participanting in research that involves measurement of body weight . Fourth, the maturation index was devised from data collected in the United States. Although mean estimates of maturity status were generally ‘on-time’, the mean values suggested a slight delay in maturity status in the two oldest age groups. This may reflect the relatively smaller group sizes or a tendency for older girls who are advanced in maturity status to opt out of the study, perhaps due to concerns about being weighed. Although British and American boys and girls aged 9-15 years present very similar mean heights and weights (Cole, 1994) (http://www.cdc.gov/growthcharts), further research is required to validate the formulae devised for predicting adult stature in North American youth in British samples. Fourth, it should be noted that the current model did not include an index of body composition (i.e., fat relative to fat-free mass). It is possible that relations between maturity status, physical self-concept, and physical activity might be further mediated by body composition. Future research should seek to examine the independent and interactive effects of maturation and body composition on physical self-concept and physical activity (Sherar, et al., in press). Finally, the PAQ-A relies on the participant's memory to assess activity levels and could potential be influenced by social desirability. Despite these limitations, the PAQ-A has demonstrated that it is a valid, low cost, and easy to use measures of activity that is well suited for use within youth (Kowalski, et al., 2004; Kowalski, et al., 1997). Although objective measures of physical activity, such as accelerometers, are ideal; these methods also have their limitations in large samples/population-based research such as cost, labor intensive data analysis, susceptibility to mechanical failure, tampering, and reactivity (Armstrong & Welsman, 2006).

In summary, this study supported the contention that early maturation in adolescent females is associated with less involvement and physical activity, and provided partial support for the Mediated Effects Model of Psychological and Behavioural Adaptation to Puberty (Petersen & Taylor, 1980) within the context of physical activity. More specifically, perceptions of attractiveness and sport competence were found to partially mediate relations between maturity status and physical self-worth, and physical self-concept was found to partially mediate relations between maturity status and physical activity. Accordingly, researchers examining maturity associated variation in physical activity and health would do well to consider the potential mediating and/or confounding role of physical self-concept.

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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.

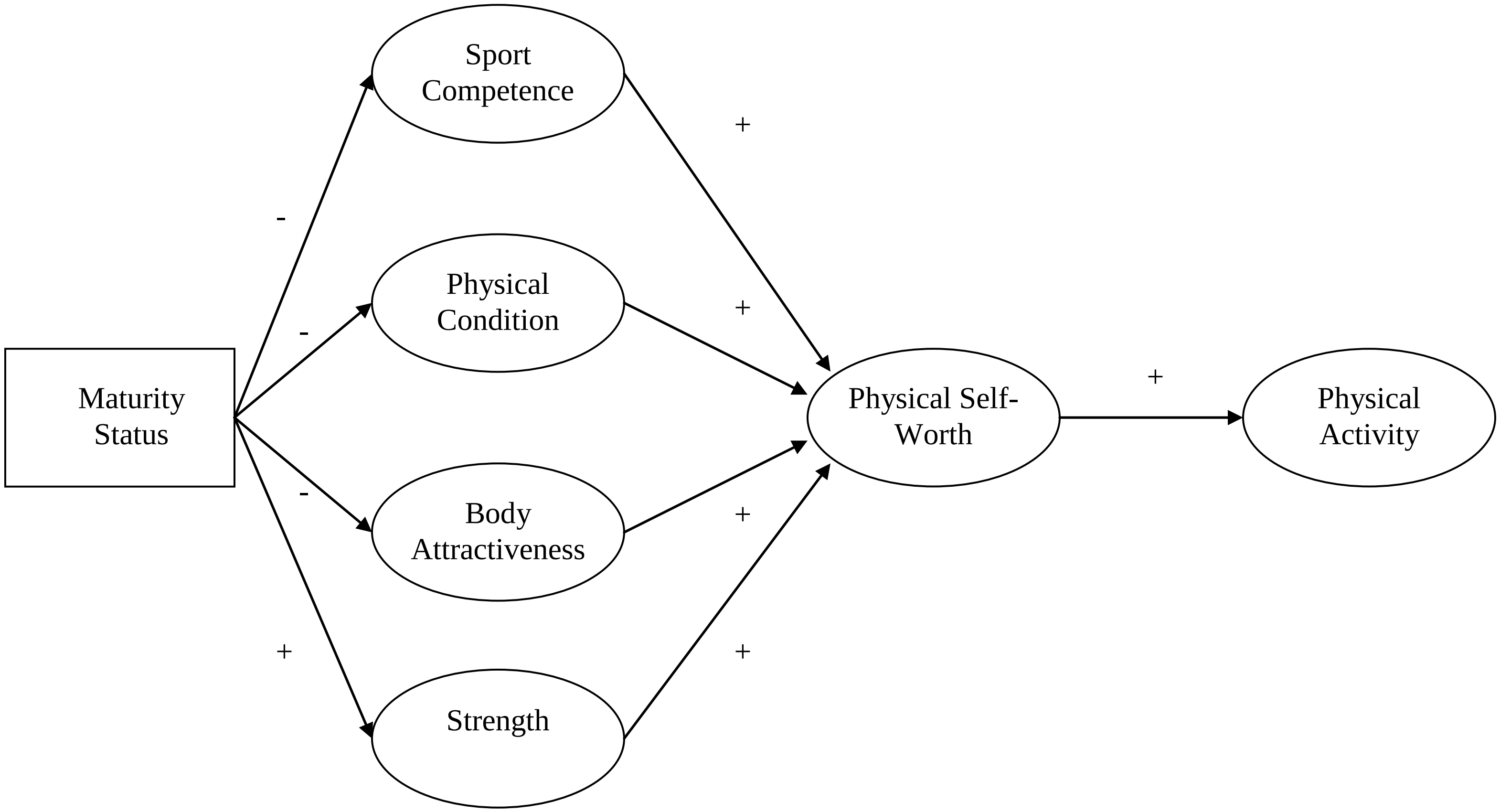
	11 years n=55	12 years n=120	13 years n=145	14 years n=73	15 years n=14
Chronological age	11.7 (.2)	12.5 (.3)	13.5 (.3)	14.3 (.3)	15.5 (.2)
Maturity status z-score	-.09 (.97)	-.10 (1.09)	-.06 (.93)	-.38 (.90)	-.65 (.68)
Height (cm)	150.4 (7.1)	154.8 (7.3)	160.0 (6.5)	161.3 (7.1)	161.7 (5.3)
Weight (kg)	43.7 (9.3)	48.8 (10.9)	53.0 (9.4)	55.9 (10.1)	55.8 (9.2)
BMI (kg/m^2)	19.1 (3.0)	20.2 (3.5)	20.6 (3.0)	21.4 (3.2)	21.2 (2.5)
Sport competence	2.81 (.61)	2.74 (.65)	2.61 (.60)	2.71 (.52)	2.50 (.61)
Physical condition	2.86 (.57)	2.76 (.64)	2.78 (.60)	2.76 (.60)	2.69 (.67)
Body attractiveness	2.63 (.71)	2.58 (.72)	2.36 (.60)	2.26 (.66)	2.28 (.78)
Physical strength	2.54 (.55)	2.62 (.59)	2.48 (.65)	2.47 (.52)	2.30 (.37)
Physical self-worth	2.82 (.56)	2.71 (.64)	2.54 (.67)	2.52 (.56)	2.38 (.58)
Physical activity	2.77 (.63)	2.57 (.65)	2.53 (.62)	2.59 (.59)	2.44 (.70)

Table 2. Pearson product moment correlations (one-tailed) between measures of estimated biological maturity status, physical self-concept, and physical activity.

	1	2	3	4	5	6
1. Biological maturity status						
2. Sport competence	-.12**					
3. Physical condition	-.23***	.68***				
4. Body attractiveness	-.29***	.46***	.43***			
5. Physical strength	.20***	.51***	.39***	.21***		
6. Physical self-worth	-.23***	.65***	.59***	.81***	.39***	
7. Physical activity	-.14**	.47***	.49***	.24***	.30***	.36***

* = p <.05; ** = p <.01; *** = p <.001

Figure 1. A mediated effects model describing the role of physical self-concept in explaining relations between biological maturity status and physical activity in adolescent British females.


Sport
Competence
Physical
Condition
Maturity
Status
Body
Attractiveness
Strength
Physical Self-
Worth
Physical
Activity
-
-
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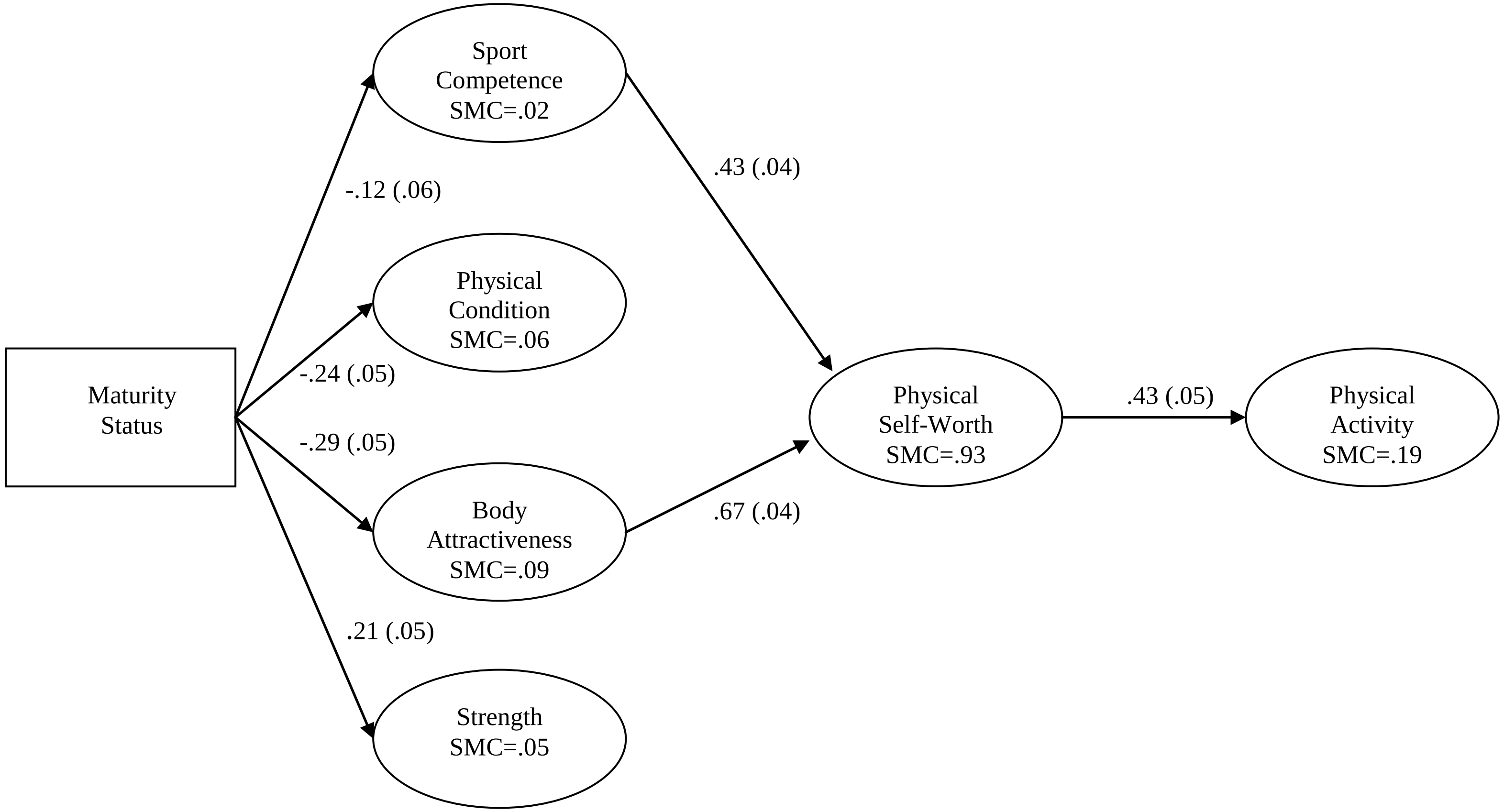
+
+
+
+
+
+

Figure 2. Revised mediated effects model describing the role of physical self-concept in explaining relations between biological maturity status and physical activity in adolescent British females.



Note. All shown parameters are significant. Indirect effects were observed between maturity status and physical self-worth (β = -.25 (BBC 90% CI = -.34, -.16), P<.001), and maturity status and physical activity (β = -.11 (BBC 90% CI = -.16, -.07), 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 four sub-dimensions of the physical-self were all significant and were as follows; sport competence & physical condition *r*=.43; sport competence & body attractiveness *r*=.52; sport competence & strength *r*=.65; physical condition & body attractiveness *r*=.45; physical condition & strength *r*=.52; body attractiveness & strength *r*=.33.