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Physical Self-Perceptions in Adolescence: Generalizability of a Multidimensional, Hierarchical Model Across Gender and Grade

Martin S. Hagger

University of Essex, Colchester, Essex, U.K.

Stuart J.H. Biddle

Loughborough University, Loughborough, Leicestershire, U.K.

C.K. John Wang

Nanyang Technological University, Singapore

Author Note

Stuart J.H. Biddle, School of Sport & Exercise Sciences, Loughborough University, Ashby Road, Loughborough, LE11 3TU, United Kingdom, email: S.J.H.Biddle@lboro.ac.uk.

C.K. John Wang, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, email: ckjwang@nie.edu.sg.

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Correspondence concerning this article should be addressed to Martin Hagger, Department of Psychology, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ, United Kingdom, email: hagger@essex.ac.uk.

Abstract

This study tested the generalizability of the factor pattern, structural parameters and latent mean structure of a multidimensional, hierarchical model of physical self-perceptions in adolescents across gender and grade. A children's version of Fox and Corbin's (1989) Physical Self-Perception Profile (C-PSPP) was administered to seventh-, eighth- and ninth-grade high school students (N = 2969). Two a priori models were proposed: a confirmatory factor analytic model proposing a multidimensional model of physical self-esteem and a structural equation model that hypothesized a multidimensional, hierarchical structure with global self-esteem as a superordinate construct and physical self-worth as a domain-level construct governing the subdomains of the C-PSPP. Using the FASEM approach (Bentler, 1986), both models satisfied multiple criteria for goodness-of-fit with the data in each individual gender and grade sample. Tests of the invariance of the factor pattern and structural parameters for both models across gender and grade were supported. Consistent with findings from other contexts, latent means analysis suggested that physical self-esteem scores were higher in boys and in seventh-grade adolescents.

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One of the most prominent constructs studied in social, educational and personality psychology is self-concept or self-esteem. There is general consensus that self-esteem comprises the perceptions that individuals have regarding themselves and has both descriptive and evaluative content (Harter, 1996). The notion of self-esteem is attractive because researchers hypothesize that it is an influential predictor of pertinent outcomes, such as academic achievement (Marsh, 1988). In addition, self-esteem has also been treated as an important outcome in itself due to its close ties with psychological well-being (Marsh, 1989a; Paradise & Kernis, 2002), and self-esteem may also predict motivational tendencies as people seek behaviors in areas of competence in order to maintain or enhance self-perceptions.

Research into the structure of self-esteem has provided considerable support for the multi-faceted and hierarchically organised model proposed by Shavelson, Hubner and Stanton (1976). This model has considerable advantages over early unidimensional approaches (Coopersmith, 1981; Rosenberg, 1979) because it recognises that self-esteem arises from multiple sources and operates in a variety of contexts. The multidimensional, hierarchical model advocated by leading researchers (e.g. Byrne, 1988c; Harter, 1985; Marsh, 1987b, 1993; Marsh & Shavelson, 1985; Song & Hattie, 1984; Yeung, Chui, Lau, McInerney, & Russell-Bowie, 2000) suggests that overall, global self-esteem governs self-esteem evaluations in a variety of domains such as social, academic, physical and occupational. In turn, the domain-level constructs are superordinate to numerous sub-facets or subdomains that represent the organisation of self-descriptive and self-evaluative statements concerning competencies in these more specific contexts. Within this hierarchical organisation, global self-esteem is regarded as relatively stable and enduring compared with domain and subdomain-level self-evaluations. Subdomain level and further sub-divisions reflect situational, more-transient and less-stable evaluations of the self.

Nearly two decades of research with the multidimensional and hierarchical model of self-esteem has yielded considerable support for its hypothesized structure. Marsh and coworkers have provided strong evidence for the validity of a broadly stated self-esteem model that incorporates many domains (Marsh, 1987b, 1996b; Marsh & Shavelson, 1985). This research has lead to the development of rigorously tested instrumentation that has demonstrated construct (Marsh, 1987b), discriminant (Byrne, 1988c) and cross-cultural validity (Wästlund, Norlander, & Archer, 2001). The multidimensional, hierarchical model has also been adopted by researchers using a divergent approach (McGuire, 1983) in their research to examine the effects of self-esteem on numerous dependent variables such as academic performance (Marsh, Byrne, & Shavelson, 1988) and achievement (Marsh, 1988), psychological well-being (Paradise & Kernis, 2002), bullying (Marsh, Parada, Yeung, & Healey, 2001) and perceived competence (Connell & Wellborn, 1991). Such studies reinforce the predictive validity of a multidimensional, hierarchically organised model of self-esteem. In addition, researchers adopting a convergent style of research (Marsh, 1997; McGuire, 1983) have shown enhanced self-esteem to be the outcome of a number of psychological processes such as competence (Harter, 1990, 1993), perceived ability (Marsh, 1987a) and perceived autonomy support (Reeve, 2002). In sum, the proposed model of self-esteem has been supported and rigorous testing of self-description questionnaires has provided valid self-esteem measurement instruments.

A key advantage of the Shavelson et al. (1976) model is that it permits the detailed study of self-esteem in a single domain whilst simultaneously maintaining the relevance of the domain to global self-esteem. Adopting the model for this purpose enables the study of the organisation and predictive validity of domain-relevant self-esteem statements but does not isolate the domain-level concept from global self-esteem. Instead, the relative contribution of the domain to global self-esteem and the mediation of the subdomain facets by the domain-level construct as implied by the hierarchy are explicitly modelled.

As a result, researchers interested in the impact of self-esteem in the physical domain have adopted this model to study its structure (Fox & Corbin, 1989; Marsh, Richards, Johnson, Roche, & Tremayne, 1994) and impact on health-related behaviors such as physical activity participation (Fox, 2000b; Sonstroem, Harlow, & Josephs, 1994), physical fitness components (Marsh, 1996a; Marsh & Redmayne, 1994; van Vorst, Buckworth, & Mattern, 2002) and eating behaviors (Frederick & Grow, 1996). Fox and Corbin (1989) proposed a multidimensional, hierarchical model of physical self-perceptions following the proposed structure of the Shavelson et al. (1976) model, and adopted the profile approach of Harter (1988) to develop the accompanying measure, the Physical Self-Perception Profile (PSPP). Using open-ended questionnaires, Fox and Corbin proposed that a general physical self-esteem construct was superordinate to four subdomain factors: sports competence, physical conditioning, body attractiveness and physical strength. In keeping with the Shavelson model, general physical self-esteem mediated the relations between the subdomains and global self-esteem at the apex of the hierarchy. The structure of the proposed model was supported in a number of studies (Fox, 1990; Fox & Corbin, 1989; Marsh et al., 1994; Sonstroem et al., 1994), and has been shown to be invariant cross-culturally (Asçi, Asçi, & Zorba, 1999; Page, Ashford, Fox, & Biddle, 1993). In addition, the predictive validity of the model has been supported (Kowalski, Crocker, & Kowalski, 2001; Sonstroem, Speliotis, & Fava, 1992) and components of the model have been shown to be important outcomes of physical activity participation (Alfermann & Stoll, 2000; Asçi, 2002; Fox, 2000a).

Recently, there has been increased interest in the importance of physical self-esteem in young people, particularly in the light of guidelines recommending the promotion physical activity participation in young people (Sallis & Patrick, 1994). The Fox and Corbin model of physical self-perceptions has demonstrated adequate validity in young people and shown considerable utility in the prediction of physical activity behavior. Whitehead (1995) introduced a children's version of Fox and Corbin's physical self-perception profile (C-PSPP) and subsequent validation studies have supported the proposed structure in young people (Biddle et al., 1993; Crocker, Eklund, & Kowalski, 2000; Eklund, Whitehead, & Welk, 1997). Furthermore, physical self-esteem components have been positively related to physical activity and sport-related behaviors. For example, Hagger, Ashford and Stambuova (1998) and Rausepp, Liblik and Hannus (2002) showed the subscales of body attractiveness, physical strength and sports competence to be positively related to physical activity participation in children, while Amorose (2001) provided support for the positive impact of physical self-esteem and perceived physical competence on exercise motivation among children in a physical education context. These data support the structure of the Fox and Corbin model of physical self-esteem in young people and indicate that physical self-perceptions are an important influence on exercise participation in young people in leisure-time and physical education contexts.

Notwithstanding the support for this model, there have been few studies examining differences in the levels of physical self-esteem from the Fox and Corbin model across gender and grade level, and no study has sought to confirm the invariance of the model structure across these moderating variables. Studies that have investigated gender and grade differences in the multidimensional, hierarchical model of self-esteem have generally been confined to examining mean differences and have neglected to confirm the invariance of the proposed factor structure. Hattie (1992) noted that the structure of self-esteem is crucial to the understanding of how the order and makeup of self-esteem may vary across groups and may be as important as differences in levels of self-esteem. Indeed, the equivalence of factor structure is considered a prerequisite step in the preliminary evaluation of cross-group generalisability of self-esteem and in the subsequent evaluation of mean differences among self-esteem components (Byrne, 1996).

Turning first to gender differences in the multidimensional, hierarchical model of self-esteem, Wilgenbusch and Merrell (1999) conducted a meta-analytic accumulation of effect sizes across studies on adolescents self-esteem using gender as a moderator. They found that males tended to have significantly higher self-perceptions on five of the ten self-esteem constructs derived from multidimensional models of self-esteem. Most notably, males tend to report higher levels of global, physical appearance and athletic/psychomotor coordination, three components of self-esteem akin to those from the Fox and Corbin model. In addition, research with the Fox and Corbin model has indicated that mean scores for the C-PSPP scale are typically one-half point lower in female adolescents than males (Whitehead & Corbin, 1997), trends which have been noted in samples in other countries (e.g. Brettschneider & Heim, 1997; Marsh et al., 1994). These findings support the notion that adolescent males tend to have higher physical self-esteem ratings than their female counterparts. One caveat to these findings is that they are confined to average levels of self-esteem rather than comparisons of structural parameters of the model. Wilgenbusch and Merrell concede that their analysis did not permit the evaluation of the structure across gender in adolescents, and stated that the observed differences may not be reflective of the equivalence of self-esteem structure across gender.

However, Byrne (1988b; Byrne & Shavelson, 1987), Marsh (1989b; Marsh, Barnes, Cairns, & Tidman, 1984; Marsh, Parker, & Barnes, 1985), van den Bergh and van Ranst (1998) and Yin and Fan (2003) have reported evidence to support the structural equivalence of self-esteem in the Shavelson et al. model across gender. Specifically, Marsh (1994) proposed an alternative model of physical self-descriptions that adhered to the Shavelson et al. model, and found evidence for the equivalence of factor structure across gender. Subsequent analyses also indicated evidence for mean differences in gender across the physical self-esteem domain and subdomains (Marsh et al., 1994), but the invariance of the mean structure of the latent constructs was not tested. To date, no study has examined the equivalence of the factor structure of the Fox and Corbin model across gender. There has also been no investigation into the invariance of the reproduced means of latent variables derived from confirmatory factor analytic models of physical self-esteem across gender. We aim to resolve this gap in the literature and hypothesize that the factor pattern and structural parameters of the Fox and Corbin model of physical self-perceptions in adolescents will be invariant across gender, as expected on the basis of previous research (Byrne, 1988b; Byrne & Shavelson, 1987; Marsh, 1989b; Marsh et al., 1994). However, consistent with previous research in self-esteem and sex stereotypes (Marsh, 1989a), we expect adolescent males to report significantly higher mean ratings of the self-esteem constructs compared with females.

There have been several studies examining the invariance of structure and mean differences in the Shavelson et al. model of self-esteem across grade level in school children (e.g. Marsh, 1989a; Marsh et al., 1984; Marsh et al., 1985; Skaalvik & Rankin, 1990). For example, van den Bergh and van Ranst (1998) examined the structural equivalence of Harter’s profile approach to self-esteem and reported very little variance across fourth-, fifth-, and sixth-grade children, although the structure across fourth- and fifth-grade children and fourth- and sixth-grade children was only partially invariant. No study, however, has examined the invariance of the structure of any multidimensional, hierarchical model of physical self-perceptions at the domain and subdomain level across grade. Further, no study has evaluated the invariance of the structure of the latent variable means in any model of physical self-perceptions across grade. Findings from other specific self-esteem domains have indicated that there tends to be a linear decline in self-esteem across grade beginning as early as the sixth-grade (Marsh, 1989a, 1990; Marsh et al., 1984), but little evidence that grade differences were moderated by gender. Studies adopting Marsh's model of physical self-descriptions have indicated significant mean differences across grade similar to the academic domain, but little evidence of grade x gender interactions (Marsh & Sonstroem, 1995). Declining confidence in appearance, increases in the search for self-identity and a rise in comparisons with others in adolescence have been cited as reasons for this decline (Marsh & Parker, 1984; Wilgenbusch & Merrell, 1999). The present study aims to add to the literature but testing the hypotheses of an invariant factor pattern and structural parameters across grade level in sixth-, seventh-, and eighth-grade children. Consistent with previous research (van den Bergh & van Ranst, 1998) it is expected that the invariance tests will be supported. In addition, we will also evaluate the invariance of the mean structure of the latent factors of physical self-perception from Fox and Corbin's model. In accordance with previous research on multidimensional and hierarchical models of self-esteem at the domain level (Marsh, 1989a; Marsh et al., 1984), it is expected that there will be a linear drop in physical self-perception domain and subdomains across grade level.

Method

Participants

Students (N = 2949, *M* age = 12.93, *SD* = .90) from 47 government-run high schools distributed throughout the United Kingdom were recruited as part of a larger nation-wide survey on physical activity and health. Within each school, a class of seventh-, eighth-, and ninth-grade students were sampled, yielding a sample comprising 914 seventh-grade (*M* age = 11.88, *SD* = .38), 1013 eighth-grade (*M* age = 12.89, *SD* = .39) and 1042 ninth-grade (*M* age = 13.89, *SD* = .37) students. Overall, the sample comprised 1551 girls (*M* age = 12.95, *SD* = .90) and 1398 boys (*M* age = 12.91, *SD* = .91). Data from the National Office for Standards in Education indicated that the school students were generally from a background that matched the socio-economic distribution of UK schools based on an income means test used to determine whether the child was eligible for free school meals.

Measures

The Physical Self-Perception Profile for children (C-PSPP; Whitehead, 1995) was used to measure physical self-perceptions according to Fox and Corbin's multidimensional, hierarchical model. The C-PSPP comprises 36-items, 6 items each for the domain-level physical self-esteem construct and the subdomain-level constructs of sports competence, physical condition, body attractiveness and physical strength. In addition, 6 items are included to tap global self-esteem adopted from Rosenberg (1979) and Harter's (1988) scales for the same construct. The C-PSPP adopts the paired forced-choice 4-point scale format used in Harter's (1988) self-perception profile for adolescents. For each item, respondents must first decide which of two self-related statements they identify with, and then decide whether that statement is "really true for me" or "sort of true for me". The C-PSPP was administered by research assistants to classes of up to 60 students in quiet classroom conditions.

Results

Single-sample analyses

The adequacy of the proposed multidimensional and hierarchical model of physical self-perceptions for each gender and grade sample (Fox & Corbin, 1989) was evaluated using the LISREL approach (Jöreskog, 1993), also known as the factor analytic-structural equation modelling (FASEM; Bentler, 1986) approach. This method stipulates that a confirmatory factor analytic (CFA) or measurement model is estimated in the first instance. In the CFA model, items from the C-PSPP are specified as indicators of latent constructs (ξ) representing their overall factor. The structural relations among the indicators and each latent factor are termed factor loadings (λ) and each is a free parameter in the model, with the exception of one indicator that is fixed at unity to define the scale of the factor (Marsh & Hocevar, 1985). In addition, the measurement error (δ) associated with each item is explicitly modelled. Further, the latent factors are all set to be correlated with each other (ϕ), as is typical in CFA models (Jöreskog, 1993). The CFA model of physical self-esteem is represented in Figure 1. The adequacy of the set of equations representing the a priori CFA model to describe the covariances among the observed items from the data sets is then tested. Theoretically, the adequacy of this model satisfies the proposed multidimensionality of Fox and Corbin's physical self-esteem model. Pending the adequacy of the CFA model, a structural equation model (SEM) was then stipulated to test the hierarchical arrangement of the self-perception latent constructs. The SEM specifies directional relationships (γ) among the predictor or exogenous (ξ) and predicted or endogenous (η) latent constructs. The satisfactory fit of the SEM with the observed covariance matrix relative to the CFA model will provide sharp confirmation of the proposed structural relations. The proposed SEM is shown in Figure 2.

In the present study, each CFA model and SEM was estimated using a robust maximum likelihood estimation method (Satorra & Bentler, 1988). Overall goodness-of-fit of the proposed models with the data was evaluated using multiple indices of good-fit rather than the goodness-of-fit chi-square which is considered over-restrictive as an evaluation of good-fit due to its sensitivity to sample size. The indices adopted in the present study were the comparative fit index (CFI, Bentler, 1990), the non-normed fit index (NNFI, Marsh, Balla, & McDonald, 1988), the standardized root mean square of the model residuals (SRMSR, Bentler, 1990), and the root mean square error of approximation (RMSEA, Hu & Bentler, 1999). Values above .90 for the CFA and NNFI are considered to be indicative of adequate model fit (Bentler, 1990), although values approaching .95 are preferable (Hu & Bentler, 1999), while values below .08 and .05 for the SRMSR and RMSEA support good model fit.

The CFA models for each individual gender and grade sub-sample yielded satisfactory goodness-of-fit indices (Table 1). Subsequent tests of the SEM in each sample also supported the hypothesized structural relations that represent the hierarchical arrangement of the C-PSPP latent factors. Although there were significant differences between the CFA models and SEM according to the likelihood ratio test, there was minimal variation among the incremental fit indices, indicating that the sensitive chi-square test was detecting differences in the models that were largely unsubstantial (Marsh, Marco, & Asçi, 2002). On the basis of these data, it can be concluded that the structural model that reflects both the multidimensional and hierarchical aspects of the proposed model is an adequate reflection of the Fox and Corbin model of physical self-esteem.

In addition to overall model fit, Joreskog and Sorbom (1993) also recommend the examination of the model solution estimates (e.g. factor loadings and reliability estimates), to permit a broader evaluation of model adequacy. The factor loadings for the observed indicators on each latent factor, the error variances of the indicators and their item content for the CFA models are given in Table 2. The loadings were all relatively large and significant for both the gender (median $\lambda = .659$) and grade (median $\lambda = .661$) samples, indicating that the latent constructs accounted for sufficient variation in their set of indicators. Bagozzi and Kimmel (1995) suggest that discriminant validity of two constructs is supported if the factor correlations are less than unity by 1.96 times the standard error of the correlation. The factor intercorrelations for the gender (Table 3) and grade (Table 4) samples all met this criterion. In addition, composite reliability coefficients (ρ) were calculated for each latent factor in both the gender (Table 3) and grade (Table 4) samples. This reliability coefficient provides a measure of the overall reliability with which the latent variable indicators are explained by the latent factor, with values above .60 considered adequate (Bagozzi & Yi, 1988). The reliability coefficients for both the gender (median $\rho = .886$) and grade (median $\rho = .877$) samples are indicative of adequate reliability. Finally, Table 5 shows the structural relations among the latent variables for the SEM in the gender and grade samples. The parameter estimates for the gender (median $\gamma = .828$) and grade (median $\gamma = .845$) samples are all large and significant, but do not approach unity. Together these solution estimates indicate that the a priori CFA models and SEM adequately account for the C-PSPP data in the present sample.

Multi-Sample Analyses

The hypothesized invariance of the factor pattern and structural parameters of the Fox and Corbin model of physical self-perceptions across gender and grade was tested using multi-sample confirmatory factor analytic and structural equation models. The invariance routine recommended by Byrne (1989) and Pentz and Chou (1994) was followed. The invariance routine was conducted for both the CFA model, reflecting the multidimensional nature of the Fox and Corbin model only, and the SEM in which the hierarchical arrangement of the model constructs was specified. Initially, a baseline model was estimated to evaluate whether the factor pattern (i.e. same number of factor and same number of indicators) was invariant across the samples. This was followed by subsequent tests of invariance of the factor loadings (λ), factor variances (ξ) and factor correlations (ϕ) for the CFA model. For the SEM model, subsequent restricted models in which the factor loadings, factor variances/factor error terms (ξ/ζ) and structural relations among latent constructs (γ) were fixed to be invariant across the samples were estimated. The models were evaluated using the same incremental fit indices used for the single-sample analyses. Cheung and Rensfold (2002) note that the evaluation of measurement invariance using the traditional likelihood ratio test is likely to yield significant differences given the sensitivity of the goodness-of-fit chi-square to sample size. The authors recommend the use of incremental fit indices with differences of .01 or less across between baseline and subsequent restricted invariance models considered satisfactory in the support of the equivalence of the fixed parameters across the samples.

Tests of the invariance for the CFA model and SEMs across gender are shown in Table 6. The baseline models exhibited adequate goodness-of-fit indices supporting the invariance of the factor pattern across gender. For both models the change in the incremental fit indices across all of the restricted models in the invariance routines was less than .01, supporting the equivalence of the structural parameters in each model across gender. The findings support a priori hypotheses that the overall structure of the Fox and Corbin model of physical self-perceptions would be equivalent for boys and girls.

Evaluating the invariance of the CFA models and SEMs over grade revealed adequate model fit for the baseline models, supporting the equivalence of the proposed number of factors and structural relations. Subsequent tests of invariance revealed differences in the incremental fit indices that were within acceptable parameters to support the invariance of all restricted sets of parameters. This indicates that the structure of the multidimensional, hierarchical model of physical self-perceptions is plausible across grade level. Furthermore, the very small differences in fit indices for the invariance tests for the CFA models and SEM suggest that a multidimensional model in which a hierarchical arrangement of factors is proposed cannot be rejected in favour of a multidimensional, correlated model for the gender and grade samples.

Testing for Invariant Latent Mean Structures

Given the invariance of the factor pattern structural parameters for the stipulated model of physical self-esteem, we then addressed the second purpose of our study, that of evaluating whether there were mean differences in the reproduced item and latent variable means across gender and grade. This involved evaluating the invariance of the matrix of reproduced indicator (intercept) means and latent variable means across the gender and grade samples (Byrne et al., 1989). The invariance routine employed to test the invariance of the structured latent means involved the specification of a baseline model which tested the plausibility of the mean structure across the samples, followed by restricted models in which the equivalence of the reproduced means of the factor indicators or intercepts and the equivalence of the reproduced means of the latent factors were specified. In order to examine the existence of mean differences, the factor means in each of the gender and grade samples were fixed at zero to act as a reference group (Byrne, 1988a).

Results of the invariance analysis of the latent mean structure of the Fox and Corbin model across gender and grade are given in Table 8. The baseline models for both samples were indicative of adequate fit supporting the pattern of structured means across the groups. Subsequent tests of the equivalence of item intercepts and latent means resulted in decreases in the incremental fit indices, although the drop was unsubstantial (Marsh et al., 2002). This supported the equivalence of the mean structure across the groups and hence we can be confident in our interpretation of the intercept and latent means. The differences in the reproduced means across gender and grade level for the latent variables are given in Table 9. This supported the a priori hypothesis that boys would rate their physical self-perceptions more highly than girls, although the higher global self-esteem mean values for boys was unexpected. For the gender samples, the means were significantly higher in boys for each of the subdomain factors, the physical self-esteem factor and global self-esteem factor. For the grade samples, there were significant differences between seventh- and eighth-grade students on all physical self-perception factors and the global self-esteem factor, while there were significant differences between seventh- and ninth-grade students on four of the six factors. Importantly, the mean differences were in the hypothesized direction indicating a trend towards lowered self-perceptions in the physical domain and global self-esteem across advancing grade.

Discussion

The purpose of the present study was to examine the invariance of Fox and Corbin's (1989) multidimensional, hierarchical model of self-perceptions in the physical domain across gender and grade in adolescents. A secondary aim was to examine whether the levels of the structured latent means of the dimensions of physical self-esteem were different across gender and grade. The results provided support for the replication of the Fox and Corbin model in each individual gender and grade sample. Importantly, the hypothesized equivalence of the physical self-perception factor pattern and structure was supported for the gender and grade samples. In addition, there was no substantial difference in the multi-sample goodness-of-fit estimates between the measurement model that specified no hierarchy and the structural equation model that specified a hierarchical relationship among the global, domain and subdomain self-esteem constructs. Overall, these results provide confirmatory evidence of the proposed multidimensional, hierarchical model across gender and grade for early adolescents. As expected, analyses of the reproduced mean values of the physical self-esteem model constructs indicated that boys' scores on all subscales, including global self-esteem, were significantly higher than girls. There were also significant decreases in self-esteem ratings across grade supporting our a priori hypothesis that self-esteem ratings tend to decline with age.

The present results provide support for the pattern and structure of the Fox and Corbin model of physical self-perceptions across gender. This corroborates the findings of previous studies using multidimensional, hierarchical models of self-esteem in other domains (e.g. Byrne, 1988b; Byrne & Schneider, 1988; Byrne & Shavelson, 1987; Marsh, 1989b; Marsh et al., 1984) and in the physical domain (Marsh et al., 1994). That the present model of physical self-perceptions is invariant across gender is pertinent per se as it provides further general support for the theoretical organisation of self-esteem proposed by Shavelson et al. However, the present findings are unique because previous studies adopting the Fox and Corbin model (e.g. Welk, Corbin, & Lewis, 1995; Whitehead, 1995) have focused solely on the mean differences in physical self-esteem scores without evaluating whether structural differences could have accounted for such differences (Hattie, 1992). Therefore the establishment of the equivalence of the structural parameters in a model of physical self-esteem is an important addition to the literature. Further, the use of both confirmatory factor analytic and structural equation models in the present study lent support for the proposed multidimensional nature and the hierarchical ordering of the physical self-esteem constructs. This was indicated by the unsubstantial difference in goodness-of-fit statistics for the confirmatory factor analytic model, representing the multidimensional nature of physical self-esteem, and the structural equation model in which directional paths among latent constructs defined the hierarchical arrangement of the self-esteem dimensions. While Marsh et al. (1994) provided support for his model of physical self-concept, his focus was on examining the multidimensionality and concurrent validity of the model using multitrait, multimethod analyses with existing instruments rather than testing the hierarchy. As a consequence, the invariance of the multidimensional, hierarchical arrangement of the Fox and Corbin model across gender is a unique finding.

Given the support for the invariance of model structure, researchers can be confident that any variance in the model intercept and factor means would not be confounded by structural discrepancies. In the present study, significant gender differences were found across all of the physical self-esteem constructs at the subdomain and domain-level as well as at the global level. These findings support the trend endemic in self-esteem research that girls tend to view their self-esteem less favourably than boys (Marsh, 1989a; Marsh et al., 1984; Wilgenbusch & Merrell, 1999). However, the tendency for girls to report lower self-esteem than boys tends to be most marked in domain-specific areas of self-esteem corroborating the use of a differentiated model of self-esteem (Crain, 1996). The tendency for gender differences at the domain and subdomain levels of physical self-esteem may occur because many of the self-esteem constructs at this level focus on specific abilities and competencies (e.g. sports competence, physical conditioning and physical strength), in which boys are typically viewed as being more competent than girls (Wilgenbusch & Merrell, 1999). Given the effect of actual and perceived ability on self-esteem (Marsh, 1987a), it is little surprise in comparative contexts like physical education that girls tend to rate such abilities lower than boys (Marquez & McAuley, 2001; Whitehead & Corbin, 1997). In addition, previous research has illustrated that girls self-concept appearance ratings tend to be depressed relative to boys (Marsh et al., 1994), and this was corroborated by the lower body attractiveness scores by girls in the present sample. Such a finding is not surprising given the pervasive nature of physical appearance among adolescent girls' values systems and reported anxiety related to physical appearance among girls in this age-group (Frederick & Morrison, 1996). Finally, results from Marsh's (1987c) study indicated that self-esteem may be "inherently more masculine" (p. 112). Since self-esteem scales tend to tap constructs such as confidence and assertiveness, qualities that are typically viewed as 'masculine' characteristics, it is to be expected that boys tended to report higher levels of physical self-esteem.

The present study also provided confirmatory evidence that the structure of self-esteem in the physical domain is invariant across school grade, a finding that is unique to this study. The invariant structure across grade is congruent with the findings of other studies adopting a multidimensional approach to self-esteem (van den Bergh & van Ranst, 1998). However, Marsh and colleagues (Marsh, 1989a; Marsh et al., 1984; Marsh et al., 1985; Marsh & Shavelson, 1985) noted that while robust, differentiated multidimensional structures of self-concept were replicable in pre-adolescent and late-adolescent children, the hierarchical organisation fit the pre-adolescent data more optimally. It was proposed that older children may have a more differentiated notion of self-concept which could not easily be explained by a global self-concept construct alone, a finding that has been corroborated elsewhere (Harter, 1982, 1985; Marsh, 1990; Shavelson et al., 1976). Thus the present study indicates that, for the period of early adolescence under scrutiny, the hierarchical structure of physical self-esteem holds and does not become more differentiated as seen in other studies. Evidence from the present study for the lack of change in differentiation among the physical self-esteem constructs across age is provided by the invariance of the factor correlations in the confirmatory factor analytic model across grade. Present findings also show that the consistency in the hierarchical physical self-esteem structure in this age group is assured by the invariant structural parameters in the structural equation model across grade. Together these findings suggest that the differentiation of self-esteem in the physical domain and changes in the hierarchy do not occur in this age group and may arise in older adolescence.

Given the equivalence of the structure of self-esteem across grade, subsequent tests of the reproduced mean levels of the item intercepts and latent self-esteem constructs indicated lower levels in all of the physical self-esteem constructs and global self-esteem for the ninth-grade sample relative to seventh-grade sample. These differences are consistent with trends toward decreases in self-esteem with age observed in the physical (Marsh & Sonstroem, 1995) and other domains (Marsh, 1990; van den Bergh & van Ranst, 1998). Since the equivalence of the structure of physical self-esteem has been supported across grade, mean differences in the level of the physical self-esteem constructs across grade can be attributed to true differences among the constructs rather than the differences being artefacts of structural variation or reliability. Therefore, alterative explanations for the mean differences need to be sought. To speculate, explanations for the differences may lie in increases of self-awareness, changing interests and behavioral patterns as children enter adolescence. Marsh (1990) claims that young children's levels of self-concept are unrealistically high and decreases in adolescence may be the result of more realistic appraisals of their abilities rather than the failings of a school environment. There is also evidence that young people's interests change as they enter adolescence and they may seek to establish areas of competence that may result in the neglect of self-esteem in other areas (Vallerand, 1997). Finally, there is evidence that young people's physical activity levels decline with age (van Mechelen, Twisk, Post, Snel, & Kemper, 2000) and may reflect increased interests outside the physical domain (Cale & Almond, 1992; Kemper, 1994) or increased experiences of incompetence in the physical domain (Williams & Gill, 1995). As a consequence, decreases in self-esteem in the physical domain may reflect experiences of incompetence in physical education classes or in physical activity participation and may, in turn, act as a source of information in future decisions to participate in physical activity. In sum, mean differences in the level of self-esteem with age should not be attributed to structural variance in the present sample, but are real differences that may reflect developmental changes in realistic appraisals of ability, patterns of interest or experiences of incompetence in physical situations.

The present study is unique as it provides a comprehensive evaluation of the structural and mean differences of Fox and Corbin's (1989) multidimensional, hierarchical model of self-esteem in the physical domain. Findings support both the multidimensionality and hierarchical structure and its invariance across gender and grade. The higher mean physical self-esteem scores for boys and children in the seventh-grade reflect differences not attributable to structural variations. Future studies need to identify the variables that explain why these differences exist, such as the perceived masculinity of self-esteem constructs (Marsh, 1987c) and changes in competence experiences in the physical domain with age (Williams & Gill, 1995). Longitudinal designs examining physical self-esteem across grade levels may also provide a more powerful assessment of structural invariance and mean differences than the cross-sectional assessment conducted in the present study.

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Table 1

Goodness-of-fit statistics for single-sample C-PSPP models

Sample	Model	SB-χ^2	df	CFI	NNFI	RMSEA	SRMSR	Δdf	$\Delta\chi^2$
Girls (*n* = 1566)	CFA	1047.993**	579	.937	.931	.044	.057	-	-
	SEM, hierarchical model	992.619**	589	.926	.921	.047	.066	10	55.374**
Boys (*n* = 1403)	CFA	963.694**	579	.944	.939	.039	.056	-	-
	SEM, hierarchical model	992.619**	589	.941	.937	.040	.057	10	28.925**
7th Grade (*n* = 914)	CFA	1040.757**	579	.932	.926	.043	.056	-	-
	SEM, hierarchical model	1094.875**	589	.925	.920	.045	.058	10	54.118**
8th Grade (*n* = 1013)	CFA	1138.355**	579	.921	.914	.048	.067	-	-
	SEM, hierarchical model	1172.041**	589	.917	.912	.048	.069	10	33.686**

Sample	Model	SB-χ^2	df	CFI	NNFI	RMSEA	SRMSR	Δdf	$\Delta\chi^2$
9th Grade (n = 1042)	CFA	946.5041**	579	.953	.949	.039	.059	-	-
	SEM, hierarchical model	992.318**	589	.948	.945	.040	.058	10	45.814**

Note. CFA = measurement confirmatory factor analytic model; SEM = hypothesized multidimensional, hierarchical structural equation model of physical self-esteem; SB-χ^2 = Satorra-Bentler scaled goodness-of-fit chi-square statistic; df = degrees of freedom for chi-square statistic; CFI = comparative fit index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMSR = standardized root mean square of residuals; Δdf = Change in degrees of freedom relative to previous model; $\Delta\chi^2$ = Change in goodness-of-fit χ^2 relative to previous model.

*$p < .05$ **$p < .01$

Table 2

Standardized factor loadings and error variances of C-PSPP factor indicators by sample

Factor, item number and item description	Factor loading (error variance)				
	Girls	Boys	7th Grade	8th Grade	9th Grade
Sports Competence					
1. Do very well at all kinds of sports	.661 (.372)	.645 (.347)	.617 (.427)	.660 (.302)	.661 (.336)
6. Wish they could be a lot better at sports	.658 (.557)	.573 (.738)	.519 (.771)	.610 (.643)	.597 (.660)
11. Think they could do well at just about any new sports activity	.605 (.397)	.475 (.517)	.553 (.465)	.489 (.541)	.629 (.336)
16. Feel that they are better than others their age at sports	.466 (.551)	.608 (.433)	.586 (.526)	.512 (.504)	.641 (.421)
21. Usually watch instead of play	.780 (.182)	.608 (.343)	.666 (.311)	.552 (.371)	.705 (.256)
26. Don’t do well at new outdoor games	.657 (.303)	.602 (.373)	.669 (.375)	.572 (.407)	.638 (.353)
Physical Conditioning					
2. Don’t feel that they are very physically fit	.569 (.456)	.513 (.519)	.505 (.541)	.547 (448)	.572 (.527)
7. Try to take part in energetic physical exercise whenever they can	.735 (.338)	.770 (.345)	.754 (.369)	.764 (.333)	.782 (.272)
12. Don’t usually have much fitness and endurance	.748 (.269)	.705 (.350)	.645 (.418)	.720 (.346)	.792 (.236)

Factor, item number and item description	Factor loading (error variance) Girls	Boys	7th Grade	8th Grade	9th Grade
17. Feel *uneasy* when it comes to exercising for fitness	.530 (.384)	.500 (.472)	.517 (.465)	.463 (.432)	.564 (.380)
22. Feel confident about being able to do enough exercise to stay very fit	.701 (.322)	.826 (.263)	.756 (.336)	.734 (.343)	.808 (.245)
27. Think that they can always do more exercise than other kids their age	.733 (.306)	.808 (.270)	.765 (.312)	.738 (.337)	.737 (.309)
Body Attractiveness					
3. Feel that they have a good looking body compared to other kids	.726 (.305)	.696 (.349)	.703 (.324)	.745 (.270)	.698 (.362)
8. Think that it's hard to keep their bodies looking fit and in good shape	.711 (.368)	.640 (.439)	.630 (.452)	.620 (.459)	.672 (.394)
13. Think that that their bodies don't look good in just shorts and T-shirt	.777 (.317)	.717 (.363)	.712 (.365)	.778 (.276)	.765 (.303)
18. Feel that they are often admired for their fit, good-looking bodies	.620 (.329)	.623 (.415)	.622 (.383)	.680 (.325)	.644 (.376)
23. Think that their bodies don't look in good shape physically	.780 (.224)	.814 (.217)	.740 (.262)	.784 (.238)	.836 (.179)
28. Are happy about the appearance of their bodies	.734 (.283)	.778 (.265)	.683 (.317)	.664 (.378)	.726 (.305)
Physical Strength					
4. Feel that they are stronger than other kids of their age	.586 (.362)	.663 (.785)	.531 (.465)	.682 (.340)	.772 (.255)
9. Think that they have stronger muscles than other kids their age	.651 (.289)	.694 (.328)	.660 (.331)	.686 (.294)	.731 (.252)

Factor, item number and item description	Factor loading (error variance)				
	Girls	Boys	7th Grade	8th Grade	9th Grade
14. Are the first to step forward strong muscles are needed	.636 (.374)	.659 (.448)	.602 (.485)	.636 (438)	.715 (.335)
19. Lack confidence when it comes to strength activities	.654 (.313)	.734 (.301)	.675 (.309)	.676 (.325)	.748 (.257)
24. Think that they are strong, and have good muscles compared to other kids	.621 (.307)	.673 (.361)	.631 (.382)	.658 (.374)	.655 (.345)
29. Feel that they are not as good as others when physical strength in needed	.790 (.151)	.739 (.256)	.756 (.225)	.740 (.233)	.789 (.197)
General Physical Self-Esteem					
5. Are proud of themselves physically	.670 (.376)	.580 (.424)	.657 (.387)	.650 (.354)	.646 (.391)
10. Are happy with how they are and what they can do physically	.774 (.275)	.645 (.384)	.685 (.362)	.655 (.386)	.714 (.333)
15. Don’t feel very confident about themselves physically	.785 (.236)	.716 (.298)	.720 (.299)	.696 (.303)	.739 (.262)
20. Have a positive feeling about themselves physically	.683 (.338)	.591 (.423)	.665 (.344)	.578 (.641)	.680 (.334)
25. Wish that they could feel better about themselves physically	.694 (.272)	.697 (.326)	.651 (.344)	.727 (.258)	.736 (.266)
30. Are very satisfied with themselves physically	.699 (.294)	.624 (.437)	.583 (.477)	.631 (.411)	.684 (.344)
Global Self-Esteem					
31. Are often unhappy with themselves	.703 (.350)	.574 (.425)	.512 (.480)	.630 (.353)	.660 (.377)

Factor, item number and item description	Factor loading (error variance)				
	Girls	Boys	7th Grade	8th Grade	9th Grade
32. Don't like the way they are leading their life	.590 (.403)	.469 (.447)	.544 (.432)	.560 (.375)	.579 (.385)
33. Are happy with themselves as a person	.539 (.469)	.569 (.482)	.560 (.456)	.563 (.487)	.531 (.456)
34. Like the kind of person they are	.651 (.451)	.610 (.401)	.695 (.352)	.649 (.413)	.679 (.317)
35. Are very happy being the way they are	.762 (.303)	.659 (.399)	.644 (.411)	.726 (.337)	.679 (.327)
36. Are not very happy with the way they do a lot of things	.640 (.355)	.615 (.363)	.664 (.353)	.590 (.415)	.616 (.345)

Table 3

Factor correlations and composite scale reliabilities among C-PSPP latent factors by gender

	1	2	3	4	5	6
1. Sports competence	(.861)					
	(.818)					
2. Physical condition	.811	(.886)				
	.816	(.884)				
3. Body attractiveness	.614	.673	(.912)			
	.690	.689	(.899)			
4. Physical strength	.720	.513	.402	(.896)		
	.749	.553	.645	(.893)		
5. General physical self-	.860	.820	.866	.568	(.910)	
esteem	.864	.817	.861	.730	(.866)	
6. Global self-esteem	.699	.664	.734	.539	.891	(.800)
	.791	.712	.703	.581	.876	(.823)

Note. Line 1 = Girls; Line 2 = Boys; Composite scale reliability coefficients are given on principal diagonal in parentheses.

Table 4

Factor correlations and composite scale reliabilities among C-PSPP latent factors by grade

	1	2	3	4	5	6
1. Sports competence	(.822)					
	(.811)					
	(.864)					
2. Physical condition	.920	(.864)				
	.725	(.875)				
	.850	(.913)				
3. Body attractiveness	.766	.758	(.888)			
	.622	.736	(.903)			
	.651	.686	(.907)			
4. Physical strength	773	.694	.770	(.871)		
	.630	.454	.539	(.892)		
	.660	.524	.596	(.922)		
5. General physical self-	.869	.801	.906	.778	(.877)	
esteem	.824	.821	.876	.603	(.877)	
	.839	.845	.828	.667	(.901)	
6. Global self-esteem	.766	.720	.786	.637	.889	(.840)
	.743	.687	.703	.565	.946	(.856)
	.699	.616	.678	.456	.791	(.864)

Note. Line 1 = 7^{th} Grade; Line 2 = 8^{th} Grade; Line 3 = 9^{th} Grade; Composite scale reliability coefficients are given on principal diagonal in parentheses.

Table 5

Standardized structural parameter estimates among C-PSPP latent factors by sample for the hypothesized multidimensional, hierarchical structural equation model

Parameter	Girls	Boys	7th Grade	8th Grade	9th Grade
Physical self-esteem→sports competence	.863	.902	.914	.825	.874
Physical self-esteem→physical condition	.822	.828	.858	.815	.856
Physical self-esteem→body attractiveness	.826	.837	.901	.845	.821
Physical self-esteem→strength	.597	.738	.808	.620	.674
Global self-esteem→physical self-esteem	.866	.861	.864	.899	.781

Table 6

Goodness-of-fit statistics for multi-sample C-PSPP models testing for invariance across gender

Model	Invariance tests	SB-χ^2	df	CFI	NNFI	RMSEA	SRMSR	Δdf	$\Delta\chi^2$
CFA	Baseline	2007.404**	1158	.941	.935	.029	.057	-	-
	λ's invariant	2058.930**	1188	.939	.935	.029	.062	30	51.526*
	λ's and ξ's invariant	2085.364**	1194	.938	.934	.030	.069	36	77.96*
	λ's, ξ's and ϕ's invariant	2113.588**	1209	.937	.934	.030	.073	51	106.184*
SEM	Baseline	2122.310**	1178	.934	.929	.031	.062	-	-
	λ's invariant	2172.515**	1208	.932	.930	.031	.067	30	50.205*
	λ's and ζ's/ξ's invariant	2179.383**	1214	.932	.930	.030	.072	36	57.073**
	λ's, ζ's/ξ's and γ's invariant	2203.999**	1219	.931	.929	.031	.076	41	81.689**

Note. CFA = measurement confirmatory factor analytic model; SEM = hypothesized multidimensional, hierarchical structural equation model of physical self-esteem; SB-χ^2 = Satorra-Bentler scaled goodness-of-fit chi-square statistic; df = degrees of freedom for chi-square statistic; CFI = comparative fit index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMSR = standardized root mean square of residuals; Δdf = Change in degrees of freedom relative to previous model; $\Delta\chi^2$ = Change in goodness-of-fit χ^2 relative to baseline model.

*p < .05 **p < .01

Table 7

Goodness-of-fit statistics for multi-sample C-PSPP models testing for invariance across grade

Model	Invariance tests	SB-χ^2	df	CFI	NNFI	RMSEA	SRMSR	Δdf	$\Delta\chi^2$
CFA	Baseline	3130.722**	1737	.936	.930	.025	.059	-	-
	λ's invariant	3202.961**	1797	.935	.932	.025	.064	60	72.239
	λ's and ξ's invariant	3220.080**	1809	.935	.932	.025	.068	72	89.358
	λ's, ξ's and ϕ's invariant	3285.170**	1839	.933	.931	.025	.070	102	154.448**
SEM	Baseline	3263.785**	1767	.931	.926	.026	.041	-	-
	λ's invariant	3337.383**	1827	.930	.928	.025	.066	60	73.598
	λ's and ζ's/ξ's invariant	3374.394**	1839	.929	.927	.025	.068	72	110.609**
	λ's, ζ's/ξ's and γ's invariant	3388.501**	1849	.929	.927	.025	.072	82	124.716**

Note. CFA = measurement confirmatory factor analytic model; SEM = hypothesized multidimensional, hierarchical structural equation model of physical self-esteem; SB-χ^2 = Satorra-Bentler scaled goodness-of-fit chi-square statistic; df = degrees of freedom for chi-square statistic; CFI = comparative fit index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMSR = standardized root mean square of residuals; Δdf = Change in degrees of freedom relative to previous model; $\Delta\chi^2$ = Change in goodness-of-fit χ^2 relative to baseline model.

*p < .05 **p < .01

Table 8

Goodness-of-fit statistics for multi-sample C-PSPP models testing for invariance of latent mean structures across gender and grade

Sample	Invariance tests	SB-χ^2	df	CFI	NNFI	RMSEA	SRMSR	Δdf	$\Delta\chi^2$
Gender	Baseline	2019.275**	1191	.942	.939	.029	.071	-	-
	Factor intercepts invariant	2146.702**	1227	.936	.934	.030	.072	36	127.427**
	Latent means and intercepts invariant	2188.942**	1233	.933	.932	.030	.075	42	169.667**
Grade	Baseline	3269.890**	1814	.933	.930	.025	.073	-	-
	Factor intercepts invariant	3404.400**	1874	.929	.929	.025	.073	60	134.510**
	Latent means and intercepts invariant	3407.506**	1880	.929	.929	.025	.073	66	137.616**

Note. SB-χ^2 = Satorra-Bentler scaled goodness-of-fit chi-square statistic; df = degrees of freedom for chi-square statistic; CFI = comparative fit index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMSR = standardized root mean square of residuals; Δdf = Change in degrees of freedom relative to previous model; $\Delta\chi^2$ = Change in goodness-of-fit χ^2 relative to previous model.

**p* < .05 ***p* < .01

Table 9

Comparisons of latent means of the PSPP-C factors

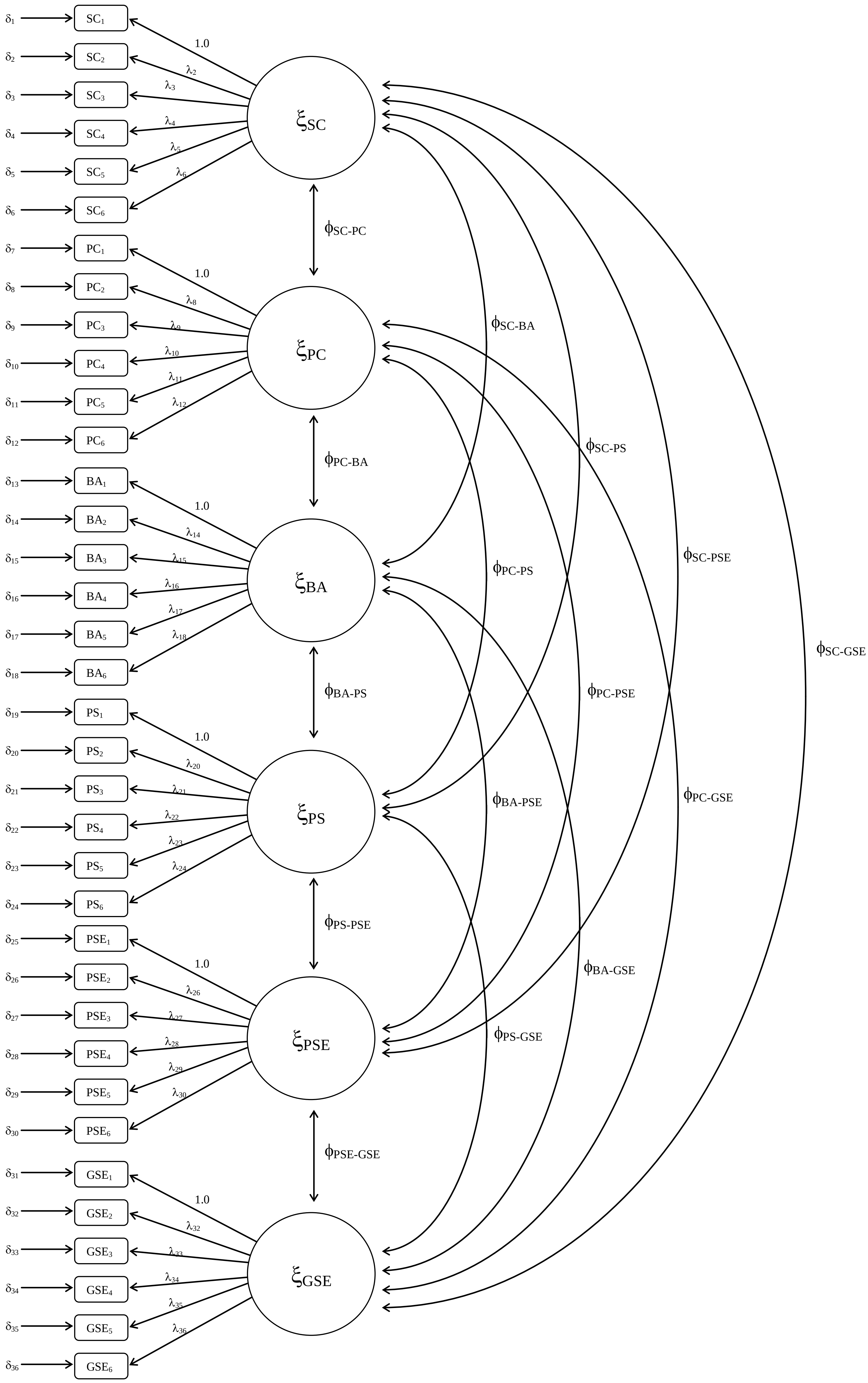
Factor	Gender		Grade		
	Girls	Boys	7^{th} Grade	8^{th} Grade	9^{th} Grade
ξ_{SC}	.000[a]	.280[b]	.000[a]	-.085[c]	-.108[c]
ξ_{PC}	.000[a]	.181[b]	.000[a]	-.043	-.074[c]
ξ_{BA}	.000[a]	.243[b]	.000[a]	-.044	.037
ξ_{PS}	.000[a]	.223[b]	.000[a]	-.022	.028
ξ_{PSW}	.000[a]	.238[b]	.000[a]	-.053	-.090[c]
ξ_{GSE}	.000[a]	.195[b]	.000[a]	-.054[c]	-.055[c]

Note. [a]Latent factor mean fixed to zero to act as reference group; [b]Means differing significantly from girls sample ($p < .05$); [c]Means differing significantly from 7^{th} Grade sample ($p < .05$); There were no significant mean differences in factor means across the 8^{th} and 9^{th} grade samples.

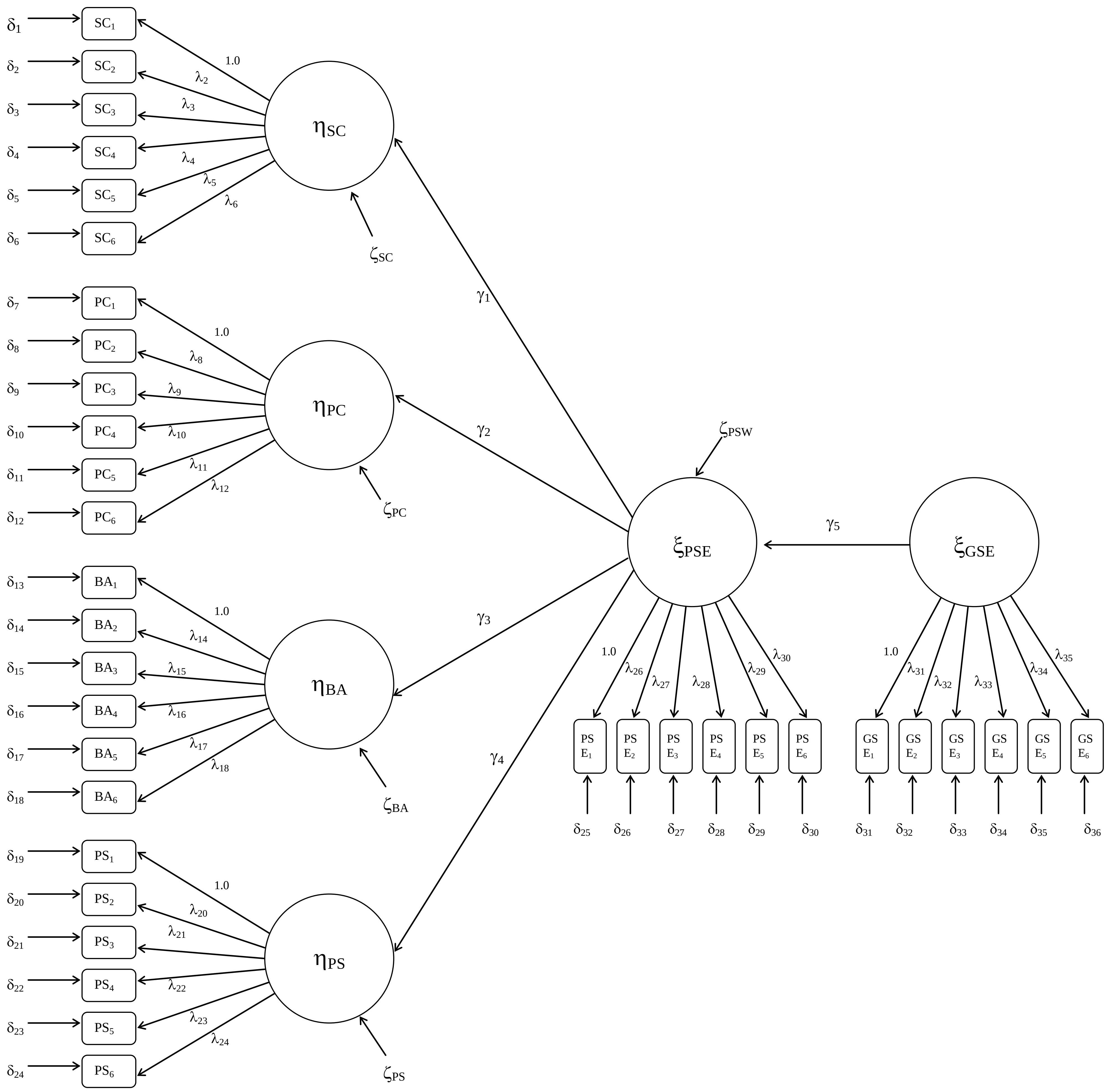
Figure caption.

Figure 1. Confirmatory factor analysis model of the sports competence (SC), physical conditioning (PC), body attractiveness (BA), physical strength (PS), general physical self-esteem (PSE) and global self-esteem (GSE) factors.

Figure 2. Structural equation model showing relations between the four physical self-perception subdomain factors, the general physical self-esteem (PSE) factor at the domain-level and the global self-esteem (GSE) factor as the superordinate.



δ_1 δ_2 δ_3 δ_4 δ_5 δ_6
SC_1 SC_2 SC_3 SC_4 SC_5 SC_6
1.0 λ_2 λ_3 λ_4 λ_5 λ_6
ξ_{SC}
$\phi_{SC\text{-}PC}$
δ_7 δ_8 δ_9 δ_{10} δ_{11} δ_{12}
PC_1 PC_2 PC_3 PC_4 PC_5 PC_6
1.0 λ_8 λ_9 λ_{10} λ_{11} λ_{12}
ξ_{PC}
$\phi_{PC\text{-}BA}$
δ_{13} δ_{14} δ_{15} δ_{16} δ_{17} δ_{18}
BA_1 BA_2 BA_3 BA_4 BA_5 BA_6
1.0 λ_{14} λ_{15} λ_{16} λ_{17} λ_{18}
ξ_{BA}
$\phi_{BA\text{-}PS}$
δ_{19} δ_{20} δ_{21} δ_{22} δ_{23} δ_{24}
PS_1 PS_2 PS_3 PS_4 PS_5 PS_6
1.0 λ_{20} λ_{21} λ_{22} λ_{23} λ_{24}
ξ_{PS}
$\phi_{PS\text{-}PSE}$
δ_{25} δ_{26} δ_{27} δ_{28} δ_{29} δ_{30}
PSE_1 PSE_2 PSE_3 PSE_4 PSE_5 PSE_6
1.0 λ_{26} λ_{27} λ_{28} λ_{29} λ_{30}
ξ_{PSE}
$\phi_{PSE\text{-}GSE}$
δ_{31} δ_{32} δ_{33} δ_{34} δ_{35} δ_{36}
GSE_1 GSE_2 GSE_3 GSE_4 GSE_5 GSE_6
1.0 λ_{32} λ_{33} λ_{34} λ_{35} λ_{36}
ξ_{GSE}
$\phi_{SC\text{-}BA}$
$\phi_{SC\text{-}PS}$
$\phi_{SC\text{-}PSE}$
$\phi_{SC\text{-}GSE}$
$\phi_{PC\text{-}PS}$
$\phi_{PC\text{-}PSE}$
$\phi_{PC\text{-}GSE}$
$\phi_{BA\text{-}PSE}$
$\phi_{BA\text{-}GSE}$
$\phi_{PS\text{-}GSE}$


η_{SC}
η_{PC}
η_{BA}
η_{PS}
ξ_{PSE}
ξ_{GSE}
ζ_{SC}
ζ_{PC}
ζ_{BA}
ζ_{PS}
ζ_{PSW}
γ_1
γ_2
γ_3
γ_4
γ_5
SC_1 SC_2 SC_3 SC_4 SC_5 SC_6
PC_1 PC_2 PC_3 PC_4 PC_5 PC_6
BA_1 BA_2 BA_3 BA_4 BA_5 BA_6
PS_1 PS_2 PS_3 PS_4 PS_5 PS_6
PS E_1 PS E_2 PS E_3 PS E_4 PS E_5 PS E_6
GS E_1 GS E_2 GS E_3 GS E_4 GS E_5 GS E_6
1.0
λ_2 λ_3 λ_4 λ_5 λ_6
λ_8 λ_9 λ_{10} λ_{11} λ_{12}
λ_{14} λ_{15} λ_{16} λ_{17} λ_{18}
λ_{20} λ_{21} λ_{22} λ_{23} λ_{24}
λ_{26} λ_{27} λ_{28} λ_{29} λ_{30}
λ_{31} λ_{32} λ_{33} λ_{34} λ_{35}
δ_1 δ_2 δ_3 δ_4 δ_5 δ_6
δ_7 δ_8 δ_9 δ_{10} δ_{11} δ_{12}
δ_{13} δ_{14} δ_{15} δ_{16} δ_{17} δ_{18}
δ_{19} δ_{20} δ_{21} δ_{22} δ_{23} δ_{24}
δ_{25} δ_{26} δ_{27} δ_{28} δ_{29} δ_{30}
δ_{31} δ_{32} δ_{33} δ_{34} δ_{35} δ_{36}