

Developmentally Informed Measurement in Sport and Exercise Psychology Research

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Whether developmental issues are of direct interest or serve as a backdrop in a given sport and exercise psychology investigation, they warrant careful attention in the framing, execution, and interpretation of the work. Though a host of theoretical perspectives on human development exist (see Horn, 2004b; Lerner, 2002), the defining feature of development is change. Importantly, this change must, at a minimum, be systematic and successive to be considered developmental (Lerner, 2002). As Lerner points out, not all change necessarily reflects a developmental process. Ebbs and flows in sport performance are common yet can stem from a variety of circumstances. The variation in opposition from competition to competition may largely explain performance variations; such a pattern of performance variation would not be considered a developmental phenomenon. However, performance variations stemming from learning, accommodation to training regimens, or adaptation to emerging cognitive capacities could be considered developmental. Thus, measurement selection and design that are developmentally informed are likely to yield the most valid and useful knowledge. It behooves sport and exercise psychology researchers to consider carefully how developmental processes may or may not underpin the phenomena that capture their attention.

Recognition of the importance of developmentally informed work in sport and exercise psychology is long standing. It is possible to find research published in the first issue of the *Journal of Sport*

Psychology that exhibits sensitivity to developmental concerns. For example, in an examination of children's success predictions as linked to sex typing of motor activities and cross-sex competition, Corbin and Nix (1979) selected participants based on developmental literature on socialization as well as issues surrounding the ability of participants to understand and offer valid responses to questionnaire items. Also appearing in the issue is the widely cited work of Smith, Smoll, and Curtis (1979) showing the effectiveness of training coaches to employ youth-centered behaviors in addressing desirable and undesirable performances of Little League baseball players.

Psychological work on youth sport increased in the 1980s, when important conceptual papers by Gould (1982), Weiss and Bredemeier (1983), and Duda (1987) were published. Gould warned against uncritically applying adult-based theories and psychological processes to youth sport research, reminding us that "the young athlete is not a miniature adult" (p. 211). Weiss and Bredemeier concluded that, based on a content analysis of youth sport psychology research, few researchers considered cognitive-developmental criteria in participant selection. They described selected theories that could be used to frame developmentally sensitive work and offered several guidelines for pursuing developmental sport psychology research. Specifically, they recommended that researchers review theoretical constructs and models available in the developmental psychology literature, evaluate the

validity of such constructs in sport settings, formulate testable hypotheses that are developmentally anchored, pursue lines of interrelated studies to capture systematic differences among and change within developmental groups, formulate conceptual working models from these efforts, and test such working models with further investigations. In line with these recommendations, Duda offered a thoughtful treatment of Nicholls' (1984) developmental theory of achievement that stimulated much research activity. In short, throughout the 1980s there was a substantial increase in attention paid to developmental concerns in sport psychology research targeting young people.

As sport and exercise psychology has broadened and matured, so too has appreciation for and understanding of developmental considerations in research. Attention is now paid to the full life span in contemporary treatments of developmental sport and exercise psychology (see Horn, 2004b; Whaley, 2007). Youth-based work has become more programmatic and theoretically driven than it has been in the past (Weiss & Raedeke, 2004). Finally, practical and technical issues surrounding the collection and treatment of developmental data have become accessible to sport and exercise psychology researchers (Brustad, 1998; Schutz & Park, 2004). Nonetheless, our understanding of developmental phenomena operating in sport and exercise contexts is restricted by overreliance on cross-sectional research designs, and we could improve both how we conceptualize our work and how we measure developmentally important constructs. As Whaley (2007) put it, "The knowledge base is there; what we seem to lack is the incentive to follow through" (p. 657).

Therefore, this chapter strives to raise awareness of developmental issues that are salient to measurement in sport and exercise psychology and to offer strategies for addressing these issues. Given the considerable scope of development-related concerns and the constraints inherent in presenting these concerns in a single chapter, we offer a treatment of selected issues that appear to be of particular importance to current research in sport and exercise psychology. Moreover, given the considerable amount of research activity on developmental issues in young people and our background in youth sport research, our discussion predominantly addresses the early years of the life span. We cover cognitive, social, and biological development in distinct subsections. We then reinforce the concept that considering change in multiple domains (e.g., cognitive *and* biological domains) is necessary to achieve the best understanding of development.

Within this discussion we also note the importance of context and behavioral assessment in developmental research. Across the sections we describe both global and specific considerations in pursuing developmentally informed measurement. That is, we showcase the importance of carefully framing research questions and selecting measures as well as address selected particulars of constructing and evaluating measurement tools. We reinforce these points with illustrations from extant sport and exercise psychology investigations that have pursued measurement in a developmentally informed way.

Cognitive Abilities and Structures

Cognitive developmental matters have garnered particular attention in discussions of developmental phenomena in sport and exercise psychology (Brustad, 1998; Horn, 2004b). This is a function of the predominant focus on cognitive variables in contemporary sport and exercise psychology theory and research. Investigators seek to understand sport and exercise behavior by tapping constructs such as motivational orientations, perceptions of the self, attitudes, and intentions. Importantly, underlying these constructs are capacities such as the ability to plan, reason in an abstract way, and acquire relevant information. Conducting developmentally informed measurement, therefore, requires careful attention to age-related differences in such capacities and familiarity with developmental theory.

The ability to process information is critical to a host of concerns in sport and exercise settings, such as skill learning, interpreting feedback, accurately deciphering the actions of teammates and opponents, and judging the causes of performance outcomes. Matters pertaining to information processing include speed of accessing information, perceptual sensitivity, and memory, all of which show age-related changes as well as experience-related changes (Thomas, Gallagher, & Thomas, 2001). Changes in the capacity for information processing are particularly rapid across childhood (see Kail, 1991) and must be considered carefully in sport and exercise psychology research on young people. Weiss, Ebbeck, and Wiese-Bjornstal (1993) offered an example of learning how to bat a baseball by viewing a batting demonstration. Younger children (approximately age 7 y or younger) have limited information processing capacities and are expected to capture only selected features of a visual demonstration. At about age 7, children are expected to shift toward attending to a breadth of visual information, including both relevant and irrelevant components (e.g., features of batting as

well as what the demonstrator is wearing). Selective attention to relevant components of the demonstration is expected around the age of 12.

The ages in the batting example are based on cognitive developmental milestones but must be considered flexible. There is considerable variability in the expression of cognitive capacities as a function of individual differences such as the amount of experience with a task. The upshot is that in studying psychological phenomena in sport and exercise settings, researchers should consider whether information processing is germane to the targeted phenomena. If so, participant selection must be considered carefully. It may also be necessary to control for individual differences associated with information processing or to include relevant measures of information processing. Alternatively, experimental measures, survey instruments, or other measurement tools should be developed for simplicity and to accommodate those participants least capable at information processing. Careful attention to information processing does not address all possible measurement challenges, as information processing is but one developmental consideration, but it does move researchers toward measurement that is more developmentally sensitive than what is often exhibited in extant research.

Another cognitive developmental consideration relevant to the study of psychological phenomena in sport and exercise is the ability to reason in abstract ways. Piaget's (1952) work has been widely influential in shaping thought on cognitive development. Piaget proposed that schemes, or mental structures underlying behavioral sequences, change over development through intellectual adaptation. More sophisticated schemes evolve as individuals assimilate experiences into their existing cognitive structures and accommodate for novel experiences that foster reconfiguration of those structures. It is through this process that egocentric reasoning characteristic of what Piaget called the preoperational period (on average, from age 2-6 y) gives way to concrete operational reasoning. Abstract thought is evident in the concrete operational stage, although it is bound by what the child can directly perceive. Ultimately, formal operational reasoning emerges around age 12. Hypothetical events can be considered, with the reasoning process drawing from what is tangibly perceived as well as the intangible. Thus, through assimilation and accommodation, cognitive structures become progressively more diverse and interconnected.

Regardless of a scholar's level of agreement with the particulars of Piaget's (1952) perspective, the differences in abstract reasoning across childhood

are evident and must be considered when studying psychological phenomena in sport and exercise. In youth-based research, theories incorporating abstract concepts such as goals, friendship, group cohesion, and intention must be applied with particular care. For example, it is not uncommon for researchers to administer to young children a questionnaire designed to assess a concept that is relatively abstract for adults. The researchers may go to the trouble of ensuring that the item wording accommodates the young children's reading skills, avoiding compound questions (i.e., questions possessing more than one element, such as those asking about *X and Y*), and offering a straightforward Likert-type response set. This is a responsible approach in light of children's information processing limitations. The children, of course, are able to select a response option for each question. The questions are similar in nature, the responses accordingly hang together, and the researchers move ahead assuming that the theoretical construct of interest is successfully measured. However, whether the questions fully or best represent the construct as expressed in children is not known. The starting point was an adult-based construct and possibly a measure that was initially developed using adult samples. A better starting strategy is to draw from developmental theory and empirical work deliberately targeting young children.

For example, researchers wishing to study achievement motivation in children must consider that the abstract concepts of ability, effort, task difficulty, and luck come to be distinguished from one another through a developmental process that extends throughout childhood and, for some, into early adolescence. In his widely cited theory of achievement motivation, Nicholls (1978, 1984, 1989; Nicholls & Miller, 1983, 1985) posited that younger children are not good at differentiating such concepts in academic domains until they acquire a mature understanding of ability and the cognitive capacity to differentiate between ability and other concepts of achievement, such as effort, relative to performance outcomes. Specifically, Nicholls suggested that children progress through several stages of development as they come to fully understand these concepts. In the earliest stage, young children cannot conceive of trying hard at something and not doing well or having high ability and not trying hard. Around age 12 y, children attain the capacity to fully disentangle these concepts such that they understand high ability is expressed when one requires little effort to achieve a top performance.

In an effort to test these ideas and extend them to the physical domain, Fry (2000a, 2000b; Fry

& Duda, 1997) conducted structured interviews with boys and girls aged 5 through 13 y after exposing them to scenarios or photos that could be interpreted differently depending on the developmental level of understanding of the target concepts of ability, effort, luck, and task difficulty. Fry adopted a Piagetian structural analysis of interview responses, assuming that the reasoning strategies children use at one stage build on the reasoning used in previous stages in a hierarchy of logic. The results of Fry's work overwhelmingly confirmed Nicholls' developmental hypotheses. In extending Nicholls' original stages, Fry and Duda also proposed a *stage 0* level of understanding, at which children are unable to identify hard work or differentiate effort from ability. Furthermore, Fry's results illuminated substantial variability within age groups in the ability to maturely differentiate tasks of varying difficulties as well as the effort and ability of individuals attempting those tasks. Relative to understanding of ability, effort, and luck, roughly one-third of participants aged 13 y had not yet achieved a fully mature discrimination of these concepts, whereas nearly all participants at this age exhibited a fully mature understanding of task difficulty. This finding reminds us that we must exercise caution with participant selection in youth-based achievement motivation research and that grouping participants by age is not a fail-safe strategy for addressing developmental questions in sport and exercise psychology that involve cognitive variables. Moreover, as Brustad (1998) pointed out, measures that require respondents to engage in complex and hypothetical reasoning must be used cautiously, if at all, with children.

The cognitive structures underlying the development of the capacity to distinguish between effort and ability are linked to other matters of deep interest to researchers in sport and exercise psychology. As an example, perspectives on moral development emphasize the reasoning about right and wrong that underlies moral action and how cognitive and social development are inextricably tied to this reasoning (see Shields & Bredemeier, 1995; Weiss, Smith, & Stuntz, 2008). In pursuing work on moral behavior in sport, therefore, researchers must take care to link cognitive capacities with the selection of participants and measures. Researchers must understand what may or may not be perceived by the target group as constituting a circumstance that involves judgments of right and wrong, because this has implications for the content of measures or for measurement strategy (e.g., open-ended structured interviews, surveys). It is expected that with greater cognitive maturity more complex reasoning

can (though might not) underlie moral behavior in sport. Therefore, attention must be paid not only to what is considered a moral concern by target participants but also to the reasoning underlying these judgments and the motivations offered for behaving a particular way.

The structure of self-descriptions and self-evaluations is also coupled with cognitive development and has been extensively researched by sport and exercise psychologists. How individuals perceive themselves and the abilities they possess evolves through cognitive maturation and life experiences (for developmental treatments relative to the physical domain, see Horn, 2004a; Whaley, 2007). Young children make self-assessments in a constrained set of domains but move toward assessment of global self-worth and discernible domains of competence (e.g., scholastic, athletic, behavioral) as they move into middle childhood. As individuals move through adolescence and adulthood, additional domains of competence become salient to the self (see Harter, 1999, 2003). This progression aligns closely with cognitive development. As the child forms the capacity to consider abstract concepts, differentiate ability from effort, and so forth, the self becomes more complex with regard to the number of competence domains and hierarchical structure. Moreover, the number of sources of competence information used to generate competence judgments increases, the salience of particular sources of competence information changes, and the competence judgments that are formed grow in accuracy (Horn, 2004).

Measuring features of the self is clearly an involved process in light of the close tie of the self system to cognitive development. The assessment strategy or tools used to capture constructs reflecting the self will necessarily differ across various phases of the life span. As showcased elsewhere (see Brustad, 1998), Susan Harter has contributed substantially to measurement of the self system across childhood and beyond. Her measures incorporate increasing and changing components of the self system across time and provide distinct tools for developmental groups spanning young childhood through late adulthood (for a table summarizing this instrumentation, see Horn, 2004a). Moreover, Harter addressed the tendency of children to offer socially desirable evaluations of the self by designing the questions to have what she termed a *structure alternative format* (Harter, 1982). The format has the respondent identify with one of two statements that describe a type of child (e.g., "Some kids often forget what they learn, but other kids can remember things easily"; Harter, 1982, p. 89). In presenting items in

this fashion, a message is communicated that half of children view themselves as falling into one category and half of children view themselves as falling into the other, legitimizing either selection (Harter, 1982). After identifying with a type of child, the respondent indicates whether the statement is “Sort of true for me” or “Really true for me,” enabling the assignment of an item score on a 4-point scale.

In extending this work to preschoolers through second graders, Harter and Pike (1984) developed a picture-based version of the measure that assesses general competence, containing cognitive and physical competence items, and social acceptance, containing peer and maternal acceptance items. Given the limited attentional capacity of young children and their inability to read and reason in abstract ways, Harter and Pike (1984) developed picture-based items that exhibit skills and specific actions in a concrete behavioral form. As with the measures employed with older respondents, the structure alternative strategy was used with this measure to reduce socially desirable responding. Two pictures are contrasted for selection by the respondent and a subsequent judgment is made with regard to how similar the respondent is to the child in the selected picture. The similarity judgment is made with the assistance of differently sized circles that correspond to appropriate descriptive statements, with higher competence or acceptance judgments corresponding to a score of 4 on a 4-point scale. Items are administered by an examiner who sits across from the child, which helps address the attentional and cognitive limitations of young children. Taken collectively, Harter’s measurement work across developmental phases has offered a useful foundation (and template) for assessing psychological constructs that are expected to evolve developmentally.

Social Development

How individuals come to understand, form attitudes about, and behave with others over time constitutes social development (Hartup, 1991). Social development is inextricably linked with cognitive development, as is evident in perspectives such as Piaget’s (1952), where social interaction can be an important stimulus for assimilation and accommodation processes. Indeed, social relationships constitute an important context for the development of the self, personality, moral functioning, and other qualities that shape how a person interacts with the environment (Hartup & Laursen, 1999). The upshot for sport and exercise psychology scholars is that social agents and social relationships may require

attention in investigations that include participants of varying developmental maturity or that target particular developmental groups. Also, because conceptions of relationships can vary developmentally, measurement of social constructs must be pursued with care.

As an example, research on the sources of information that individuals use to judge their physical competence suggests that social agents must be carefully considered in examinations of physical self-perceptions. Horn has pursued a line of research (see Horn, 2004a; Horn & Amorose, 1998) exploring the importance that young people place on various information sources such as social comparison, evaluative feedback, goal achievement, and game outcome when judging their competence. This work suggested that as youths move through the later childhood years and toward the early adolescent years, peer comparison information and peer and coach evaluative information increase in importance, whereas parent feedback declines in importance. Adult feedback comes to be considered as one piece of information among several options and is not necessarily taken at face value, reflecting a more mature understanding of others as well as of concepts such as ability. As a person advances through the adolescent years, feedback sources are further differentiated from one another, and internal sources of information become increasingly important (Horn, 2004a). Progressing through the adult years, the person must come to terms with potential decline in physical capabilities, a process that can interconnect goals, self-perceptions, and the tendency to compare personal physical capacities with those possessed by others (see Frey & Ruble, 1990; Semerjian & Stephens, 2007; Whaley, 2007). In short, there is developmental change in the magnitude and form of social influence on physical self-perceptions. Therefore, scholars pursuing work on well-being, physical activity motivation, or other topics in which physical self-perceptions hold a prominent role should consider measuring relevant social constructs.

Researchers should draw from developmental theoretical perspectives and empirical work in selecting the relevant social constructs. Given the work by Horn, a researcher interested in physical activity motivation of middle schoolers, for example, may wish to specifically assess peer constructs to complement the assessment of physical self-perceptions and other motivation-related constructs. There is a rich literature on peer relationships within developmental psychology and an emerging literature within sport and exercise psychology (see Smith & McDonough, 2008; Weiss

& Stuntz, 2004). Much of the work is inspired by Sullivan's (1953) interpersonal theory of psychiatry. This theory suggests that in older children and adolescents it is important to consider both broader acceptance by the peer group and specific friendships. Peer acceptance and friendship are related constructs, and yet they offer distinct contributions to development and can accommodate for one another in circumstances where either construct is experienced at a suboptimal level. For example, poor acceptance by the larger peer group in middle school physical education might be buffered by a high-quality friendship in that setting. Ideally, then, these constructs are distinctly measured and considered simultaneously in data analyses.

Considering the level of social complexity of focal social constructs is important in formulating a measurement plan (see Holt, Black, Tamminen, Fox, & Mandigo, 2008; Rubin, Bukowski, & Parker, 2006). Peer acceptance, for example, can be gleaned from an individual-level measure of perceived acceptance, an assessment of behavioral interactions among peers, interactions over time among actors of particular characteristics (i.e., a relationship level), or group-level sociometric information. Thus, choosing the most appropriate measure or battery of measures to employ in an investigation requires careful attention to relevant theory and the specific research aim. The target sample must be considered in this decision-making process. Ideally, measures of the social (and other) constructs exist that are developed specifically for use with the target sample. If such measures do not exist, either an existing measure for a different target group needs to be modified or a new measure needs to be carefully constructed and evaluated. The latter strategy is preferable for a variety of reasons, though often the former is used because of the intensive time demands involved in producing a new measurement tool. One key reason why the effort may be worthwhile is that social and other constructs often take on a different form or meaning as a function of developmental status. We showcase this next by using the construct of group cohesion.

Group cohesion is a key group variable in sport. It is tightly associated with personal, team, environmental, and leadership factors as well as group and individual outcomes (see Carron, Hausenblas, & Eys, 2005). Carron (1982) defined group cohesion as "a dynamic process which is reflected in the tendency for a group to stick together and remain united in the pursuit of its goals and objectives" (p. 124). With his colleagues, Carron forwarded a conceptual model and associated measure of cohesion called the Group Environment Questionnaire

(GEQ; Carron, Widmeyer, & Brawley, 1985). The GEQ taps four constructs corresponding to group integration and individual attractions to the group crossed with task and social aspects of the group, respectively. The conceptual model and GEQ were generated in an effort to bring order to the cohesion research literature, and in the more than two decades of work since, there has been tremendous benefit to the knowledge base (see Carron et al., 2005; chapter 35 in this book). One troublesome challenge in the study of group cohesion in sport, however, is associated with using the GEQ with athletes other than young adults. The nature and function of interpersonal relationships are known to vary developmentally (see Rubin et al., 2006), and the measure is appropriately generalized only to young adult samples. There is particular interest in understanding group cohesion in adolescent athletes, and yet work employing the GEQ with such samples has shown suboptimal reliability and issues surrounding factor structure (Schutz, Eom, Smoll, & Smith, 1994; Westre & Weiss, 1991). These findings point to the need to pursue deliberate, foundational work on cohesion in adolescents.

Eys, Loughhead, Bray, and Carron (2009a, 2009b) pursued such work to enhance the conceptual understanding and measurement of group cohesion in adolescent sport. As a first step, Eys and colleagues (2009b) pursued qualitative work to obtain an understanding of what cohesion means to young athletes. Specifically, team sport athletes ranging from 14 to 17 y were recruited to participate in focus groups. The discussion groups included participants from both sexes and from a variety of sports so that a comprehensive understanding of cohesion could be obtained. Relative to team or physical activity groups, participants were asked how they would define cohesion, characteristics of cohesive and noncohesive groups, and ways cohesion can be developed. Analysis of responses involved deductive categorization into task or social aspects of cohesion followed by inductive categorization of meaning units into similar themes. Themes falling within task cohesion included working together, effective communication, chemistry/bonding, understanding the abilities of others, shared task experiences, unselfishness, effective peer leadership, commitment, status parity, and the coach relationship with team. Themes falling within social cohesion included knowing one another, friendship, getting along, provision of support, lack of conflict, engaging in outside activities, and lack of cliques. Participants reported coach behaviors, practice structure, shared task experiences, development of commitment, and development of task support

as means of developing task cohesion in sport and physical activity groups. They reported getting to know each other, engaging in outside activities, and developing friendships as ways to develop social cohesion. Of note relative to the extant literature on adults, the researchers did not find the participants to offer meaning units corresponding with individual attractions to the group. Rather, the group integration aspect of Carron and colleagues' (1985) model characterized the bulk of responses.

Eys and coworkers (2009a) used these reports of cohesion as well as open-ended responses of another 280 adolescents who were current and former team sport athletes and a search of the cohesion literature to generate items for the Youth Sport Environment Questionnaire (YSEQ). Because responses did not suggest dimensions of cohesion beyond those represented in the GEQ, items were generated to tap the four components of cohesion represented in the GEQ. The wording of the items and the instructions was designed to be at a lower grade or reading level than that of the original GEQ, so as to be appropriate for youths. After careful evaluation and trimming of items by the investigators, 120 items were submitted to three sport psychologists with group cohesion expertise and five high school athletes for commentary on conceptual appropriateness and understandability. Following this process, a reduced set of 87 items was retained for subsequent administration to a group of adolescent team sport athletes. Response distribution patterns of items from this administration were examined, resulting in the removal of 30 more items from the YSEQ. Scores on the remaining items were submitted to a set of principal components analyses, with the final analysis yielding 17 items represented by two principal components. The two components reflected social and task aspects of group cohesion, respectively.

In the final phase of the research effort by Eys and colleagues (2009a), the 17-item version of the YSEQ was administered to 352 adolescent team sport athletes. Confirmatory factor analysis specifying the two-factor social and task model showed acceptable fit to the data with the removal of 1 underperforming item. The final YSEQ that emerged from this process is expected to yield group cohesion scores that offer a more valid account of this important group construct in adolescents than would the adult-validated GEQ. Theory informed the initial production of items, and yet the item content came from adolescents themselves. The data suggest that, unlike what has been observed in adults, adolescents do not distinguish between group integration and individual attractions to the

group dimensions of cohesion. Overall, this work provides a nice example of how a social construct can take on different forms across developmental groups. This highlights the importance of considering social development in sport and exercise psychology measurement.

Biological Maturation

The bulk of growth and maturation research focuses on changes occurring up to young adulthood because of the dominant biological activities that occur throughout the first two decades of life—a time that coincides with widespread involvement in sport and other physical activities. According to a review by Eisenmann and Wickel (2009), determinants of physical activity are biologically inherent, as represented by heredity, sex, adiposity, and sexual maturation, and these are especially important for research examining habitual physical activity. Moreover, as noted in a recent review by Dorn, Dahl, Woodward, and Biro (2006), while puberty is often conceived of as a predominantly biological process, it is not simply a matter of physical change. Puberty includes a synchrony of physiological, neurobehavioral, and social changes that affect individual perceptions, cognitions, emotions, and behaviors. Thus, consideration of biological factors is important when designing research investigations in sport and exercise psychology.

Though biological factors are integral to psychological phenomena in sport and exercise, adequate assessments of biological variables are surprisingly absent from most research designs. Many researchers collect information on the age of participants; however, age is simply the marking of time (Wohlwill, 1973) and is not a reliable indicator of developmental stage. This is particularly the case when pubertal processes are under way. Dorn and colleagues (2006) have argued that pubertal assessments are at least as important as specifying the age of participants when conducting adolescent research. Unfortunately, as these authors point out, there is considerable inconsistency in the methods, definitions, and conceptualizations of puberty and its stages. This inconsistency likely has served as a disincentive to include pubertal assessments in sport and exercise psychology investigations.

Considering biological growth and maturation can be especially helpful in shedding light on developmental sport and exercise psychology questions. *Growth* is defined as an increase in size or body mass, whereas *maturation* refers to the timing and tempo of progress toward a mature biological state (Malina, Bouchard, & Bar-Or, 2004). Height,

weight, and body mass index (BMI; the ratio of weight in kilograms to height in meters squared) are the most common assessments found in the literature, but researchers can also consider skeletal breadths (e.g., shoulder-to-hip ratio), sitting height, leg length, and the ratio of sitting height to stature when seeking understanding of growth and maturation. Biological maturation is often discussed in terms of status and timing. *Maturity status* refers to the state of maturation at a given point in time. Assessments include skeletal age or a variety of methods for calculating the percentage of mature height at a specific chronological age (see Malina et al., 2004). Children who are the same chronological age can be categorized as prepubertal, pubertal, and postpubertal. In addition, girls can be categorized as pre- and postmenarcheal when age at menarche is ascertained through questionnaire or interview. On average, girls reach their greatest tempo of growth, termed *peak height velocity* (PHV), at 11.5 to 12.0 y, while boys reach PHV at 13.5 to 14.0 y. Velocity is faster for boys. They grow approximately 3.5 in. (9 cm) a year, whereas girls grow about 3.1 in. (8 cm) a year. Growth in stature tapers off at about 14 y in girls and 17 y in boys (Beunen & Malina, 1988). The longer growth time frame for boys accounts for the height difference, which is attributed to growth in the long bones (i.e., leg length), generally seen between adult men and women. Although weight is susceptible to extrinsic factors such as nutrition and physical activity, peak weight velocity follows PHV by 2.5 to 5 mo in boys and 3.5 to 10.5 mo in girls (see Haywood & Getchell, 2009).

An individual's state of biological maturity is relevant for several reasons. Boys advanced in maturation tend to be more successful in sports such as soccer and hockey, whereas girls later in maturation tend to be more successful in gymnastics and figure skating. Thus maturity status can influence sport selection (Malina, 1998). Maturity assessments also can help inform practitioners about training loads appropriate for young athletes and therefore can help to reduce injury risk (Johnson, Doherty, & Freemont, 2009). There is greater risk associated with heavy training loads when an individual has not reached a biologically mature state. Of course, with such physical risks also come potential psychological risks, such as diminished physical self-perceptions, sport motivation, and overall well-being. This is a connection deserving of close research attention. Suggestions that intensive training during the adolescent growth spurt delays achievement of physical maturity, particularly in females (Bass et al., 2000), must be balanced with an understanding of the heritability of menarcheal timing (Towne

et al., 2005). This more comprehensive treatment of maturity can help researchers refine questions pertaining to physical activity outcomes such as the female athlete triad (disordered eating, amenorrhea, and osteoporosis). Clearly, research designs that capture biological maturity, and not just age, enable more robust explanations of various sport and exercise phenomena.

Timing of biological maturation refers to when specific biological events take place. For example, the average age at menarche among Caucasian girls is 12.8 ± 1.0 y (Malina et al., 2004). This age has been used to categorize study participants as early (<11.8 y), average (11.8-13.8 y), and late (>13.8 y) maturers. Because age at menarche is a continuous variable, it can be used as a covariate, as can the number of years since menarche (chronological age – menarcheal age). Other events such as the timing of PHV and how quickly or slowly children pass through sexual maturation (tempo) vary considerably among individuals and can significantly influence sport and exercise experiences among children. For example, two athletes on a team may be the same age and the same height at a given assessment time, but one may have attained 80% of adult stature while the other may have attained 65% of adult stature. Both athletes will attain fully ossified skeletal systems but will do so at different times, and the later-maturing athlete will grow for a longer time frame, surpassing the earlier-maturing athlete in adult stature.

In an effort to account for interindividual size variation when addressing developmental or other questions, researchers frequently use weight and BMI as control variables. For example, in studies examining physical self-perceptions, body image, or disordered eating, BMI may be partialled out in correlation analyses, entered in preliminary steps of hierarchical regression analyses, or used as a covariate in mean difference tests. BMI, though, is only a proxy for fatness, a quality of interest in some investigations. A widely known limitation of BMI is that the distribution of fat and muscle mass is not differentiated in the weight component of the index, meaning that individuals can have a high BMI because of lean muscle, a characteristic common to some athletic populations. Other estimates of body fat are available and found in the extant literature; however, they also should be interpreted with caution. Fat mass is inherently unstable, especially during adolescence, and there is error associated with the assessment techniques (for a review, see Malina et al., 2004). Technological methods that partition body composition into fat mass and fat-free mass (e.g., dual-energy X-ray

absorptiometry, or DXA) are available, but they are costly and impractical for large-scale sport and exercise psychology investigations.

Quantifying physique is another way to account for physical characteristics. Assessments include shoulder-to-hip ratio (i.e., the ratio of bicristal to biacromial breadths), the androgyny index, and somatotype, an objective indicator of physique representing relative fatness, muscularity, and linearity. Somatotype is expressed in terms of endomorph, mesomorph, and ectomorph components that can range from 0 to infinity; however, most values are less than 7.0 (Carter & Heath, 1990). While such objective physique indicators should be appealing to researchers, anthropometric assessment training and reliability establishment are time consuming. Compared with using X rays for skeletal maturity assessment, estimating the time before or after PHV from age (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002), which is known as *maturity offset*, is a less intrusive, more robust alternative for assessing maturity status that can be used in psychological investigations. For example, maturity offset has been linked to correlates of disordered eating, such as social physique anxiety, among adolescent athletes (Gay, Monsma, & Torres-McGehee, in press). However, maturity offset also has limitations; equations are valid only for males and females aged 9 to 16 y, and there are validity limitations for homogenous samples of participants short in stature (Malina et al., 2006). Thus, as is the case when selecting cognitive, social, and other biological measures, it is important for researchers to consider carefully their research aims and their target subject population when using this measure.

Change in Multiple Domains

The presentation of the previous sections offers structure to the present chapter but is somewhat artificial in that clearly many of the developmental changes described coincide and interact with one another. For example, the relative timing of physical maturation in light of the social concerns of young people appears to influence the development of the self in girls, whereby early onset of puberty is a disadvantage (Malina, 2002). Physical maturational timing can also link to skill development outcomes, serving as a person cue that shapes performance expectations of important social agents such as teachers and coaches, who may in turn behave in ways that result in the expectation being confirmed (see Horn, Lox, & Labrador, 2010). Most certainly the confluence of developmental experiences faced by participants in sport and physical activity can

influence socialization, motivation, performance, and other outcomes of interest to researchers.

For us to understand developmental experiences, our research designs must systematically consider variables from both biological and psychological paradigms (Burwitz, Moore, & Wilkinson, 1994; Sherar, Cumming, Eisenmann, Baxter-Jones, & Malina, 2010), or what is often termed the *biocultural perspective* (e.g., Malina, 2002). There are useful models that offer insight as to how biological and psychological factors interplay in contextually specific ways. For example, Newell's (1986) model of developmental constraints suggests that movement-related outcomes arise from interactions among structural (physical) and functional (behavioral) characteristics of the individual, environmental influences, and specific task features. Lerner's (1985) contextual theory also calls for including physical characteristics and specifies a matching hypothesis that helps to explain positive and negative valences of behaviors as the quality of match, or mismatch, between the individual (physical and psychological characteristics) and the task demands. These models showcase the importance of the individual interacting with the environment and serve to inform research designs. In a review of adolescent physical activity behavior, Sherar and colleagues (2010) suggested important future research directions, including (1) considering the discordance between subjective self-reported indicators and objective assessments of maturity status and how these measures associate with psychosocial variables; (2) sampling boys and girls from the extreme ends of the developmental continuum to capture what maturational timing means to individuals at varying ages; (3) considering social desirability, as it may be associated with self-reported maturational timing; and (4) assessing how to alter contexts to decrease possible negative outcomes stemming from variation in maturational timing.

Attending to context when pursuing understanding of psychological phenomena is also critical in developmental research (Kagan, 2007). Body-related perceptions, for example, may be especially salient in sport contexts in which aesthetics are subjectively judged, significant others emphasize weight control, and athletes reach their performance prime before adulthood (see Malina, 2002). A person's perceived social acceptance may vary as a function of the specific peer context within which the person interacts with others, be it highly competitive sport, physical education, or the neighborhood setting. Of course, broader community and cultural factors come into play as well, making for many layers of potential influence on developmental outcomes. For

this reason, ecological viewpoints that emphasize the interaction of individual and extraindividual influences on human behavior have begun to capture the attention of developmental sport and exercise psychologists (e.g., see García Bengoechea, 2002; Welk, 1999). From a measurement standpoint, it behooves researchers to consider carefully how extraindividual influences might be accommodated and operationalized within sport and exercise psychology investigations.

Developmental researchers should also carefully attend to observable behaviors, an endeavor that has been argued to be underemphasized in contemporary sport and exercise psychology research (Andersen, McCullagh, & Wilson, 2007; Hagger & Chatzisarantis, 2009; Weiss & Raedeke, 2004). Behavioral assessment is critical for the understanding of, for example, sport and exercise motivation, learning of movement skills, and interpersonal relationships in sport. Such consideration goes hand in hand with measurement of internal states and perceptions, which helps capture underlying motives, understandings, and self- and other-directed evaluations that are theoretically and practically important. Assessing observable behaviors and internal states in tandem can allow clearer understanding of psychological phenomena, as often it is the combination of these elements that offers explanatory value. In fact, relying on only one assessment strategy can lead to significant misunderstanding of a phenomenon of interest.

The study of observational learning illustrates this point. Observational learning, also referred to as modeling, is defined as the cognitive, affective, and behavioral changes that result from observing others (Weiss et al., 1993). Coaches and physical education teachers rely heavily on demonstrations to teach new physical skills, and researchers in sport psychology and motor learning have taken interest in the effectiveness of such demonstrations. Adopting a narrow measurement strategy, a researcher or practitioner interested in a young child's learning of a movement skill may rely only on that child's ability to physically reproduce what has been demonstrated. However, the failure of a young child to produce the movement may not necessarily reflect an absence of learning. The child may indeed understand the steps involved in and the purpose of a given movement. This understanding reflects learning at a cognitive level. The inability to physically reproduce the task could be tied to an absence of foundational skills, insufficient physical strength, a context that is not well suited to displaying the behavior (e.g., trying to use adult-sized implements or having

insufficient practice time), or some combination of these (see Bandura, 1986; McCullagh & Weiss, 2001). Thus, sound measurement requires researchers to pay attention to the breadth of components that undergird a phenomenon of interest.

Beyond directing attention to the importance of global measurement strategy in sport and exercise psychology, this example offers a platform for discussing developmentally informed measurement. Previous skill exposure, current strength levels, and the fit of the performance context with a performer's capacities are intertwined with the developmental status of the performer. Had the young child in the example been an adolescent with intensive sport experience, we might generate different hypotheses about why a modeled movement task that is cognitively learned is not physically reproduced. Presumably the adolescent would have an extensive movement skill background and possess the physical qualities needed to produce the modeled task. In this case, a motivational explanation for the absence of successful movement production might be forwarded based on Bandura's (1986) perspective on observational learning. This perspective specifies that attention to and retention of information, behavioral reproduction, *and* motivation are fundamental considerations in the observational learning process. Perhaps the adolescent prefers to display only well-learned behaviors in front of peers or will only halfheartedly attempt to adopt new skills when the current skill set has afforded competitive success. Thus, incorporating measures of motivation-related constructs into the study of observational learning in adolescents may be warranted. This example illustrates the critical importance of considering development (and, of course, theory) when adopting a measurement strategy to understand psychological phenomena within sport and exercise contexts.

Conclusion

Considering developmentally informed measurement from a global standpoint, meaningfully advancing the sport and exercise psychology knowledge base requires careful attention to measurement across cognitive, social, and biological dimensions of human functioning along with other individual (e.g., emotional) and extraindividual (e.g., behavioral context) contributors to human development. Moreover, researchers can benefit from considering the integration of these factors in their work and drawing from developmental theory when designing investigations. Relative to the particulars of conducting developmentally

informed work, among other things it is important for researchers to understand the limitations of age as a proxy for developmental status. It is also essential that measures be designed and assessed using participants from the population of interest rather than to presume that modifications of assessments used on other developmental groups suffice to capture target constructs. These recommendations and many of the other points in this chapter are not

new; however, as mentioned before, they are often not put into practice. This may reflect the lack of incentive noted by Whaley (2007) that owes in large part to the labor-intensive nature of conducting developmentally informed research. However, as sport and exercise psychology matures, it becomes increasingly necessary for us to go to the trouble of attending to these issues if we are to meaningfully advance the knowledge base.

