

# A Systematic Ecological Model for Adapting Physical Activities: Theoretical Foundations and Practical Examples

Yeshayahu Hutzler  
Zinman College

This article proposes a theory- and practice-based model for adapting physical activities. The ecological frame of reference includes Dynamic and Action System Theory, World Health Organization International Classification of Function and Disability, and Adaptation Theory. A systematic model is presented addressing (a) the task objective, (b) task criteria, (c) limitation and enablement criteria, (d) performance errors, and (e) adaptation suggestions. Four individual case examples are described, referring to the conceptual model and depicting its use in various settings of physical activity, including physical education, rehabilitation, competition, and recreation.

Adapted Physical Activity (APA) includes the profession, field of study, and practice that provides answers to the many problems associated with physical activity issues in both segregated and inclusive environments (Hutzler & Sherrill, 2007; Sherrill, 2004). In the most recent revision of the By-Laws of the International Federation of Adapted Physical Activity (IFAPA, 2004, p. 3), also appearing in the on-line *European Bulletin of Adapted Physical Activity* (retrieved March 10, 2005), APA is defined as “a cross disciplinary body of knowledge directed toward the identification and solution of individual differences in physical activity. . . . APA includes, but is not limited to, physical education, sport, recreation, dance and creative arts, nutrition, medicine, and rehabilitation.”

According to this definition, as well as that of the European Thematic Network on Adapted Physical Activity (De Potter, 2003), four tracks of physical activity practices are identified and require specific professional consideration: (a) rehabilitation, (b) physical education, (c) recreation, and (d) sport performance.

Textbooks in adapted physical education (e.g., Block, 2007; Liebermann & Houston-Wilson, 2002; Sherrill, 2004) provide information relative to both general adaptation principles as well as specific adaptations to typical educational activities. Textbooks in adapted sports (e.g., DePauw & Gavron, 2005; Goodman, 1992, 1994, 1996, 1997, 1998; Moore & Snow, 1994) have emphasized performance and recreation opportunities for adapting new activities. The use of activity adaptation in rehabilitation has been acknowledged by physical and occupational therapists

(e.g., Valvano, 2004), but little concern has been demonstrated by APA specialists for life-long activity adaptations promoting the rehabilitation process. In addition, current resources do not address practitioners' needs to explicitly develop unique adaptations given the individual extent of disability, individual goals and attributions, physical activity history of the individual, environmental influences, task demands, etc. This is because the adaptations addressed in textbooks and other sources do not emanate from a holistic view of the human being and are incapable of capturing the complexity of his or her interaction with an unfamiliar environment. Therefore, adaptations cannot be taken as "off the shelf" solutions, with cookbook type prescriptions of "if this . . . then do the following." Also, adaptations are not always necessary just because a person has a specific disability of a certain type. Critical thinking and decision-making processes are warranted to promote participation of individuals with disabilities in a variety of physical activity settings (Bouffard & Stream, 2003; Reid, 2003; Sherrill, 2004). A central question remains relative to how critical thinking of physical activity professionals may be facilitated (Bouffard & Stream, 2003).

Although "identification and solution of individual differences" appears in the core of the previously cited APA definition, the research database pertaining to designing, describing, and analyzing adaptations to physical activity for participants with disabilities is limited to a number of case studies (Berbane & Block, 1994; De-Paape, 1985; Houston-Wilson, Dunn, van der Mars, & McCubbin, 1997; Karlyvas & Reid, 2003; Lieberman, Dunn, van der Mars, & McCubbin, 2000; Obrusníková, Block, & Válková, 2003; Ward & Ayvazo, 2006; Webster, 1987) and controlled studies (Hedrick, 1985; Valentini & Rudisill, 2004; Vogler, Koranda, & Romance, 2000). Most of these studies have addressed adaptations in school environments, based on a pedagogical rationale rather than a comprehensive theory of adaptation.

Thus, the purpose of this article is to propose a theoretical- and practice-based approach for designing, describing, and studying adaptations via an integrated perspective called "Systematic Ecological Modification Approach," which focuses on enhancing participation through ecological adaptation in various settings of physical activity.

## Theoretical Foundation

In the following section, three theoretical frames of reference that provide support and connect to the practical model that will be described. The first theoretical frame has been slowly developing within the APA knowledge base during the past 15 years, recently acquiring greater visibility (Davis & Broadhead, 2007; Sherrill, 1995; 2004). The second is widespread within the rehabilitation community, and the third has been taken from a rather recent development in the APA literature. All three frameworks utilize the ecological understanding of individual-environment interrelationship, thus complementing each other in providing the rationale for our model.

### Action Systems Theory and Ecological Task Analysis

The ecological action system can be represented as dynamic triangular relationships between the individual, the environment, and the task labeled as action systems

theory (Kiphard, 1983; Reed, 1988) or dynamic systems theory (Newell, 1986). The essence of both is very similar; accordingly, individuals possess resources such as their size, weight, coordination, speed, strength, and psychological attitude enabling them to cope with environmental challenges. The performance outcomes, referring to both environmental and personal variables, is likely to be a rather unique pattern. For example, a person who is 2.10 meters tall would need to duck under the doorway, while a person who is 1.80 meters tall could easily walk under the doorway without bending over to get through. Each task requires a specific relation between an individual and the environment, such as changing a position from one point in space to another, crossing a distance, or catching flying objects. The goal of a task may be purposefully determined by the individual or imposed by environmental stimuli, such as teaching, instruction, or therapeutic treatment. In the ecological view, movement patterns emerge according to affordances and constraints. An affordance is viewed as the utility of an object or an environment for an individual with certain capabilities (Gibson, 1977). For example, water in a pool at chin height is "swimable," but at knee height it is "walkable." Affordances initiate an attempt by an individual to accomplish a task, and the movement pattern that emerges is determined by task-related, personal, and environmental constraints. Constraints are viewed as properties of the individual, the task and the environment that limit the motion degrees of freedom and impose the system into certain patterns of movement (Newell, 1986). For example, the task of throwing a dart at a dartboard, which requires accuracy, results in a throwing pattern that is different than a track and field athlete throwing the javelin for distance. The acquisition of motor skills under this view is a process of mutual interaction between the performer and his or her environment.

A great step forward in putting this theory into practice was the development of the Ecological Task Analysis (ETA) model (Davis & Burton, 1991) as an applied instructional and assessment system. The active experimentation of a participant with his or her environment proposed in this model is enhanced through educational intervention, leading to a potential of pattern shifts. Although the ETA model was developed 15 years ago, it has not yet substantially penetrated APA theory or the practice-related literature. The model proposed in this article borrows from ETA the stepwise process and the actual experimentation while acquiring environmental stimuli, as well as the concept of choice, critical for creative decision making, empowerment, and self-determination (Bouffard & Stream, 2003; Reid, 2003).

An important addition to the theoretical framework of ETA is the work of Thelen and her colleagues (Thelen & Smith, 1994; Thelen & Ulrich, 1991; Ulrich, Ulrich, & Collier, 1992), who have suggested a set of principles for understanding the specific relations between environmental and the individual's conditions that cause movement patterns to change. According to these principles, patterns are spontaneously explored and selected by the individual depending on contextual criteria known as rate limiters and control parameters. Rate limiters are specific relations limiting the natural selection process, and control parameters are relations facilitating a selection. Thus, the acquisition of motor skills can be interpreted as preferred patterns selected through exploration. For example, Burton, Greer, and Wiese-Bjornstal (1993) adopted this theory to examine the dynamic relations of body and ball conditions for controlling the change between preferred patterns in throwing and grasping. Their explorative work has indicated that transitions from a

one- to two-hand grasp were made as ball diameters increased but remained constant at a certain relation between hand and ball size. Thus, it may be suggested that the relation between ball diameter and hand size can be considered a control parameter for a one-hand grasping pattern. The concept that specific relations between the individual and the environment patterns may enhance or limit learning is important for the practice of APA, since it suggests a rationale for individually-tailored learning processes rather than predetermined instructions or “off the shelf” suggestions as often practiced in general physical education and sport instruction.

## **World Health Organization Classification of Function and Disability**

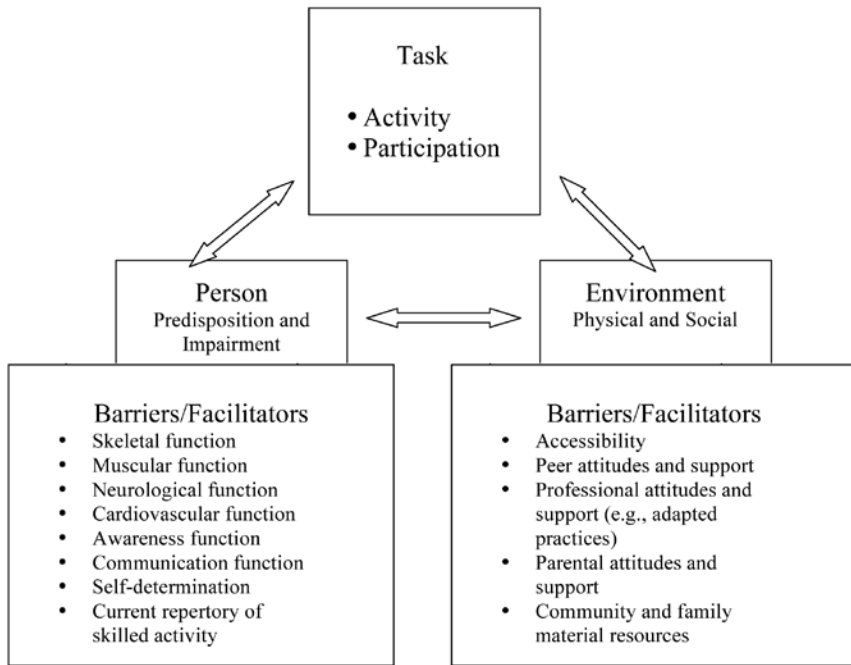
The same major components underlying Action System Theory (individual, environment, and task) have also been addressed by the International Classification of Functioning, Disability, and Health (ICF; Ústún, 2003; WHO, 2001), now accepted worldwide. This taxonomy provides criteria for classification, assessment, and intervention in health and disability. ICF addresses three major terms describing the range of potential limitations to the interactions of an individual with his or her environment. These include (a) impairment of the affected body structures (e.g., lungs, joints, limbs, brain) and functions (e.g., respiration, range of movement, muscular strength, motor control, decision making); (b) limitation in activities required for daily living, vocational engagement, and leisure time; and (c) restriction of participation in socially appropriate activities (WHO, 2001). These functions, activities, and participation are related to health conditions and contextual variables including individual predispositions and environmental factors that could be perceived as facilitators (enablers) or barriers (limiters). Figure 1 illustrates an extended triangle model, including some of the basic variables that could facilitate or limit function, activity, and/or participation.

Implementing ICF terms within APA requires some reformulation of activity goals and outcomes and the identification of service providers, practice strategies, and significance to the participant as proposed by Hutzler and Sherrill (2007). The categorizations of functional capabilities and impairments, activity limitations, and participation restrictions (WHO, 2001) within a person-environment context may assist in specifying the APA's target populations, intervention modalities, assessment tools, and outcome measures. Thus, it is expected to become a commonly accepted platform for service provision and research design in APA (Hutzler & Sherrill, 2007).

## **Adaptation Theory**

In her landmark essay on Adaptation Theory, Sherrill (1995) acknowledges the ecosystem as one of the meta-theories underlying the core paradigm of Adapted Physical Activity (APA), suggesting that

Our body of knowledge extends beyond skills and fitness to function, the ability to function in mainstream sport and exercise. . . . Now we realize that it is unjust to assess only the individual with a disability. We must assess his or her environment, or ecosystem, and identify the attitudinal, aspirational, and architectural barriers and affordances that interact to impact the learning and practice of physical activity. (Sherrill, 1995, p. 34)



**Figure 1** — Extended ecological model of facilitating and limiting variables for adapted physical activity (Hutzler, 2007).

Today, the ecological system view is central to the principles of APA (Sherrill, 2004). This view holds that adaptation is a fundamental, interactive, and reciprocal process of change between the individual and the environment. It entails modifying, adjusting, or accommodating relationships within elements of the ecosystem (Sherrill, 2004). Based on Darwin (1859), it can be further asserted that adaptation is a mode of coping with competition or environmental conditions on an evolutionary time scale. Species tend to adapt when succeeding generations emphasize beneficial characteristics. Humans are able to differentiate and even forecast beneficial outcomes within very short time durations prior to or following events. *Adaptations* and *supports* are increasingly being implemented as legal facilitators for enhancing participation (e.g., AAMR, 2002). Adaptation has also been acknowledged within theoretical frameworks of health professions such as physical therapy and occupational therapy (Valvano, 2004). Thus, adaptation theory is understood in this paper as a generic frame of knowledge for enhancing human potential that is practiced when the participant is required to act under limiting conditions.

## Systematic Decision-Making Model

The ETA model of Davis and Burton (1991) provides a practice-related model to enhance the potential of pattern shifts through educational intervention. Following the experimental work of Burton et al. (1993), it may be suggested that if

parameters controlling change from noneffective to effective movement patterns are recognized, they could be systematically modified to produce a pattern shift. Within the framework of developing adaptation and inclusion practices in physical education in Israel, continuous experimentation with ETA was conducted as a basis for a more comprehensive practical decision-making model (Reiter, Talmor, & Hutzler, 2004). This experimental model, called Systematic Ecological Modification Approach (SEMA), differs from the original ETA model (Davis & Burton, 1991) in the following perspectives: (a) it links the task goal to ICF terminology; (b) it includes an element of identifying objective and subjective criteria referencing for effectiveness of goal accomplishment; (c) it includes a specific call for evaluation of limiting and facilitating factors in accordance with ICF; (d) it includes systematic rather than arbitrary manipulation of variables enhancing activity and participation, based on a classification that has been increasingly accepted in practice (Lieberman & Houston-Wilson, 2002; van Lent, 2006); and (e) it encourages, but does not require, choices for selecting a movement form. Thus, the main independent variable is adaptations rather than choice that allows for pattern change.

The SEMA was applied when analyzing a collection of 25 individual cases in different curricular sub-areas, including fundamental motor skills, lead-up games, ball games, gymnastics, dancing, athletics, and swimming (Hutzler 2004). Each of the cases was described using a short story, a methodological dilemma, a series of potential answers to the dilemma, and a complete analysis and discussion of each case using the SEMA. A detailed description of the SEMA follows.

## **Task Objective**

The first element of the approach is to identify the task that is the center of the ecological frame of reference. Tasks are expressed as anticipated functional outcomes with respect to the relationship of an individual with his or her environment (Reed, 1988). In terms of the ICF, a task could be an activity outcome, such as throwing or catching a ball or swimming a breast stroke, but could also be a participation outcome, such as participating in a soccer game or a swimming competition. Based on the ecological approach, tasks are not imposed on the participant but identified through a collaborative process (Davis & Burton, 1991; Goodwin, 2003; Sherrill, 2004) enhancing self-determination and empowerment (Bouffard & Stream, 2003; Hutzler, 2003; Reid, 2003).

## **Performance Criteria**

Each task objective is associated with criteria for appropriate performance. These may relate to kinematic or mechanical descriptions of moving a participant's body and related objects with respect to environmental demands. Such criteria are often measured in gait and other types of movement analysis (Kirtley, 2006). Criteria may, however, also be described in a qualitative manner, as for example in the case of fundamental motor skills (Gallahue & Ozmun, 2002; Haywood & Getchell, 2005; Ulrich, 2000). These criteria are used within the SEMA as one way of addressing task goal standards. Other standards are normative performance outcomes, such as distance of ball thrown, time needed to perform a 100 m run, etc. Criteria may also be provided to account for performance in activity and participation measures in the

form of qualitative criteria (e.g., Liebermann & Houston-Wilson, 2002; Obrušníková et al., 2003; Valentini & Rudisill, 2004; Ward & Ayvazo, 2006) or quantitative outcomes (e.g., academic learning time or number of times group members have hit a ball during a certain period; De-Paepe, 1985; Webster, 1987).

## **Limitation and Enablement Criteria**

According to the ICF (WHO, 2001), limitations (barriers) manifest as (a) deficits in the individual's functional abilities of the various body systems, for example cognitive, perceptual, motor control, muscular strength, and range of motion and (b) environmental limitations such as height of the net for a wheelchair user playing volleyball, size of the soccer court for a person with cerebral palsy, distance from an observed object for a person with a visual disorder, etc. Enablement is derived from personal and environmental factors recognized as promoting functioning at a satisfactory level of activity and participation. One example of such a factor is upper body strength in individuals with paraplegia.

## **Performance Errors**

Errors in performance processes and outcomes are deviation from the patterns recognized most effective for completing a task. For example, bending the arms while performing a hand stand would increase the degrees of freedom resulting in decreasing the stability and increasing muscular strength required, thus most often causing the participant to fail in achieving the desired task goal of stabilizing the body on the hands for a certain amount of time. Identifying errors is the way most teachers perceive and describe the inability of a student to cope with task criteria. Practical textbooks typically follow error descriptions with suggestions for enhancing instructional cues and feedback practices (e.g., Krause, Meyer, & Meyer, 1999). Without a complete ecological analysis, however, the teacher may be unaware of the individual and environmental constraints leading to the performance errors observed, and thus his or her instructional strategies may be useless or even contraindicated. For example, passing a ball in volleyball to a teammate usually requires having a steady platform. If a participant fails to pass a ball in a dynamic position, he or she would usually be instructed to pass the ball from a static position, i.e., while standing still. For individuals with a certain condition such as cerebral palsy, standing still would provide an increased barrier, as plantar flexed feet and internally rotated hips limit the base of support. In such a case, it may be easier to achieve dynamic balance rather than static balance.

## **Adaptation Suggestions**

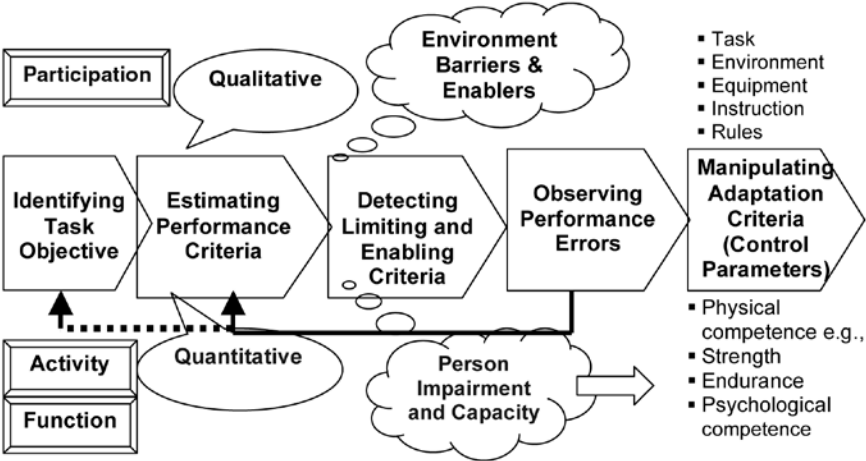
Actual adaptations should be the result of a critical analysis of the relationship between environmental and individual criteria whose manipulation could be used to pursue beneficial pattern shifts during movement skill acquisition or within a group activity, in spite of the limiting conditions. This definition is in accordance with the concept of control parameters used in the Dynamic Systems Theory. Such manipulations are typically operationalized as adaptation suggestions for (a) modifying task criteria, which can be manifested using a different skill (e.g., wheeling



a wheelchair instead of running) or as changing specific technical criteria, such as extending an arm sideward during a long jump performed by an athlete with a leg amputation, thus correcting for the asymmetric inertia; (b) modifying environmental conditions such as court size, treadmill speed, slope, etc.; (c) modifying the equipment used such as size of the ball or racket, etc.; (d) modifying the game rules such as proposing affirmative action strategies; and (e) modifying the instruction modalities from verbal instruction to manual guidance in cases of students with intellectual disability (Hutzler, 2004; Sherrill, 2004).

It should be noted, however, that sometimes it may be more beneficial to replace a task goal with another one, rather than to modify the activity for achieving desired outcomes. For example, if the functional conditions of an individual do not permit fast and accurate movements required in ball games, then the task goals should be revised. In this case it is not realistic to address a competitive goal orientation but rather a goal orientation that concentrates on task mastery. Considering this example, one should not expect to include children with severe conditions such as tetra-spasticity or multiple disabilities in a competitive ball game. The complex demands of attention and performance under multiple task conditions and extreme time pressure are likely to result in failure, disappointment, frustration, and consequently, avoidance. A mastery-oriented collaborative group task might be an alternative activity for facilitating integration into physical education in this case. Parachute games, where participants are required to join their efforts for keeping the ball on the parachute, are one of the most well known examples for such an activity.

Figure 2 depicts a summary model of the systematic ecological modification approach. The model incorporates (a) task objectives as functional outcomes of an individual-environment relationship, also characterized as the activity or participation categories of ICF; (b) task qualitative and quantitative criteria of phenomena typically described as skills or behaviors; (c) limitation (barriers) and enablement



**Figure 2** — Model description of the systematic ecological modification approach.



(facilitators) criteria depicting personal and environmental contextual factors in ICF terminology; (d) performance errors, for which adaptation is required; and finally, (e) a list of adaptations proposed to reduce errors in performance or to generate new performance criteria. In the section that follows, application of the model to school, recreation, rehabilitation, and elite sport interventions will be discussed.

## Examples for Practicing the SEMA

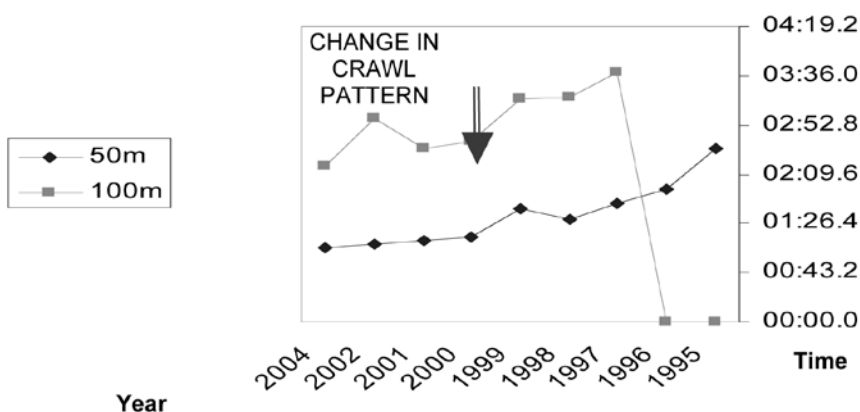
The model provided in Figure 2 offers a plethora of alternatives for systematic ecological modifications in physical activity and sports, based on two major principles of theoretical framework: (a) identifying relations between the functional capabilities of individual and environmental context variables and (b) constraining these relations for achieving shifts in activity patterns. Examples of the practical application of the SEMA decision-making model follow, depicting such an application in a variety of activity settings including sport performance, rehabilitation, recreation, and physical education.

### Swimming Technique

Eric (pseudonym) has cerebral palsy with three limbs severely impaired as well as limited trunk movement. He has practiced swimming since the age of four. It took him several years to achieve independent swimming and at the age of 16, he became a competitive swimmer. While coaching him, the first decision was to choose the task: swimming for performance (i.e., being as fast as possible) or swimming for rehabilitation (i.e., decreasing strength asymmetry and improving range of motion of the impaired arm). The coach, the swimmer, and his family have agreed to choose the performance objective. His swim stroke was analyzed and it was determined that the impaired arm was limiting performance by causing an increased drag. Thus, the swimmer was instructed to change the stroke by resting the impaired arm near the chest, so that the other arm would develop full speed. During preparations for the Sydney Paralympics, another deviation from the typical stroke developed when the swimmer started to breathe with a full body roll to the side, making the stroke of his effective arm longer. Ultimately the body position completely changed to a constant roll on the longitudinal axis, i.e., with one shoulder always sinking in the water and the other shoulder always outside of the water. Modifying task attributes, i.e., body position, together with equipment adaptation (wearing a buoyant swimming suit, which helped to decrease leg sinking) appeared to decrease drag and apparently was a major contributor to the achievements of this swimmer as seen in his performance across time (Figure 3). Table 1 describes the systematic task and activity modification process according to the SEMA model.

### Development and Individual Fitting of Petra Running Cycles

In 1990, during the World Games for the Disabled in Assen, the Netherlands, athletes with cerebral palsy participated in class 2 track race events propelling their wheelchairs backward. One of them eventually approached an occupational therapist named Connie Hansen, a former Paralympic wheelchair racing champion, and



**Figure 3** — Performance time by participation year of swimmer Eric (pseudonym).

**Table 1 Systematic Ecological Modification Approach for the Crawl Stroke in a Swimmer With Tetra Spasticity**

Qualitative Criteria of crawl swimming	Limitations	Performance errors	Adaptations
Arm pull	Asymmetric movement; impaired arm ineffective	Limited force and length of arm pull	Impaired arm rests on the body, decreasing spasticity
Arm recovery	Impaired arm increasing drag effective arm unable to leave water	Uses sculling and arm recovery in the water	Effective arm pulls with increased ROM utilizing trunk extension
Leg kick	Unable to use effective leg to kick downward	Ineffective kick increasing drag	Effective leg performs Kicks side- and downward
Passive and active body position	Limited buoyancy	Legs are sinking	Body kept on the side shoulder down
Breathing	Unable to roll side-ward; raises head upward	Often swallows water and stops	Breathing easier since no need to roll

ROM = Range of Motion

asked her to help him in the design of an improved piece of equipment for racing. As a result of this cooperation, a new movement pattern and athletic discipline that enabled race running in a forward direction with the tricycle were developed. This solution was called “Petra” after the Logo of the 1992 Barcelona Paralympic games. The new solution offers several advantages over the previously practiced backward leg wheeling and accomplishes the same task of fast locomotion in spite of the limiting conditions of severely impaired balance and leg strength. The running cycle enables the athlete to support him or herself on the saddle and the frontal body support plate, while steering the frontal wheel with the handlebars. The large diameter back wheels are directly attached to hubs in the tricycle frame, increasing the inertia derived from the runners’ steps and increasing the speed of forward movement. This option has developed into a variety of specific gait patterns, such as the butterfly and the gallop, never previously described as human gait alternatives.

The personal fitting of this sport equipment is extremely challenging, since it is related to a number of factors such as arm, trunk, and neck muscle strength, and particularly endurance. Similar positions may have different movement outcomes, since with sufficient arm and trunk strength, an upright position may contribute to a phase shift toward supported reciprocal running, while without these control parameters, a leaning position on the frontal body support plate and handlebars may be preferred with gallop or butterfly patterns likely to appear (Petra by Connie Hansen, 2002). These are bilaterally controlled patterns using bilateral arm stabilization on the frontal handlebar followed by a bilateral leg push-off from the floor. This gait enables endured weight bearing performance in spite of the very limited motor control. Table 2 shows task criteria and alternatives of fitting this equipment to participants with severely limited motor control.

**Table 2 Systematic Ecological Modification Approach for Fitting a Running Tricycle**

<b>Qualitative Criteria of gait</b>	<b>Limitations</b>	<b>Performance errors</b>	<b>Adaptations</b>
Reciprocal gait	Reduced bilateral differentiation and limited leg-trunk strength	Inability to perform reciprocal gait	Bilateral butterfly or gallop gait with low saddle position and a frontal trunk supporting plate
Gait cycle: hill strike, loading response, push off	Limited range of motion in ankle joint; reduces contact to forefoot	No hill strike and limited push off; short steps with limited effective force	High upright position supporting loading response push off and increasing step length
Constant cadence of 60-80 per min	Limited strength endurance	Sudden bursts of steps	External support and much motivational feedback

**A Skill-Related Physical Fitness Test**

In general physical education classes, it is quite common to set physical fitness standards that must be met in order to pass the examination. These standards are usually applied by means of formal or specially designed test batteries. While standards for a variety of participants with limiting conditions have been established for health purposes (Winnick & Short, 1999), some teachers still prefer skills related rather than health related performance criteria and rely on self-constructed standards based on the student population. Although a student with disabilities may be integrated in these classes, such standards may not apply to the student’s condition. The typical reaction of the class teacher is to exempt the student from the task, thus excluding him or her from the challenge of a physical fitness test, rather than adapting the test to accommodate the child’s capabilities.

Our case describes a student with a spastic syndrome similar to the diplegia type of cerebral palsy who was included in a general class. The student expressed his interest in taking the fitness test. In collaboration with the teacher, the child, and an adapted physical activity consultant, a modified fitness test battery was designed. Standards were created based on preliminary results and the test was successfully accomplished. Some of the adapted test items are available on the internet at <http://www.adaptip.com/showDoc.asp>, using a search path of condition = 2 legs; activity area = fitness; task = all. Table 3 addresses the task and activity modification approach to the fitness test.

**Final Examination in Calisthenics**

Girls participating in high school PE classes often demonstrate their ability in calisthenics by performing an individual gymnastics exercise accompanied by rhythmic music. This may be a major threat to individuals with coordination disorders. Debby (pseudonym), a teenager with cerebral palsy, was incapable of standing and walking

**Table 3    Systematic Ecological Modification Approach for an Activity Related Fitness Test for a Participant With Diplegia**

Qualitative Criteria Fitness Test	Limitations	Performance errors	Adaptations
Running	Leg spasticity and reduced ROM in hip, knee and ankle joints. Plantar flexed gait	Reduced velocity and stability	Supported movement along a course
Change direction	Spasticity limits rate of acceleration/deceleration	Increased acceleration and deceleration time	Perform over a bench
Cross obstacles	Reduced leg ROM and spasticity limit jumping	Inability to cross obstacles	Perform over a bench

ROM = Range of Motion

**Table 4 Systematic Ecological Modification Approach for Designing an Exercise in Calisthenics for a Participant With Tetraspastic Cerebral Palsy**

Qualitative criteria calisthenics	Limitations	Performance errors	Adaptations
Basic standing position	Incapable to stand without walking aids (crutches)	Can't stand	Lying and 6-point stand or knee stand positions
Leg exercise	Limited leg ROM at hip and knee joints; no ROM at ankle joints	Reduced range, differentiation, and force in all leg movements	Use mostly bilateral movements and activate trunk (e.g., rolling) rather than leg differentiation
Arm exercise	Reduced coordination of arms with 80% ROM in shoulder joints	Limited arm function; sometimes needs to keep balance in position	Arm movements performed from stable 6-point position
Combined arm and leg exercise	Limited coordination of contra lateral movements	Arm associated movements expected	Reduce open-chain positions and increase supports

ROM = Range of Motion

without walking aids (a pair of crutches) and has severe coordination dysfunction. In order to enable her to participate in the exercise contest, Debby attended extra classes individually with an APA specialist, who helped her with the choreography and selection of positions and movement patterns included in the exercise, resulting in a highly appreciated routine. The systematic modification approach (Table 4) took into consideration her limiting conditions in balance and coordination, and quadruped or lying positions to increase the base of support were incorporated. Further, the limb coordination was limited to exercises with arm only, or one arm and one leg only, in order to decrease complexity.

## Discussion

This article described the development, purpose, and examples of using the Systematic Ecological Modification Approach for integrating individuals with disabilities into physical activity and sports. Use of the SEMA as an extension of the ETA model proposed by Davis and Burton (1991) for teaching and training purposes is expected to produce the following outcomes: (a) an increase in effectiveness of adaptation, due to a more goal directed analysis; (b) an increase in efficiency of

adaptation, due to decreased experimentation time; and (c) a decrease in superfluous adaptations, which may inhibit participants' self-efficacy and socialization. The examples described in this article may be used to reflect on professionals' practices and to increase current intuitive use of ecological modification, thus creating shifts from nonefficient patterns and activity dropout to efficient patterns enabling participation within a variety of physical activity settings. In accordance with Dynamic System Theory, the SEMA proposes a structured analysis of control parameters across fundamental and sport specific skills and therefore contributes to increasing adaptation accuracy.

Relating the approach presented here to ICF criteria, it may be argued that task goal, criteria, limitations, and control parameters are typically considered exclusively at the activity level. However, each of the pattern adaptations also contributes to an increased participation level, since the action is more efficient and the participant experiences mastery, self-efficacy, and self-competence, resulting in increased motivation to try out similar adaptations in future engagements.

Relating the SEMA model to published research may provide an opportunity to systematically follow adaptations used in these articles and their impact on participation level. Hedrick's explorative work (1985) is one example of how instruction modalities (with respect to the level on the integration—separation continuum) have been manipulated for enhancing activity and participation of individuals with disability. He assigned adolescents who are wheelchair users to four participation groups: (a) under separate instruction in both teaching and playing, (b) under separate instruction in teaching and integrated playing, (c) under integrated conditions in both instruction and playing, and (d) a control group without instruction and playing. Intervention took place during eight instruction sessions and four playing sessions. Integrated groups included age matched nondisabled participants at a one-to-one ratio.

The results indicated significantly increased anxiety and reduced self-efficacy and performance in the group that was integrated in both instruction and playing, suggesting that full integration might be a barrier to both acquiring the skill and to developing motivation to participate, due to reduced performance and self-efficacy perceptions. The participants of the group that were instructed under integrated conditions but played separately achieved nearly similar results to those who were separated from the beginning, suggesting that integration during instruction of a new skill should be carefully designed and include a variety of modifications with respect to physical demands, role modeling, and strategies. Using the SEMA in such a way may have provided further attention to the adaptation modalities, and this may have had an impact on outcomes such as specific rule adaptations (e.g., adding the two-bounce rule for the wheelchair player) or environmental adaptations related to the court size (e.g., decreasing it for the wheelchair users as opposed to maintaining the original size for the nondisabled players).

Although the results of this study have never been replicated and may not reflect current inclusion practices, it should be noted that ecological modification should always enhance empowerment and self-determination of participants. If increased anxiety and reduced self-efficacy are experienced because of a modification attempt, participants are also likely to experience higher degrees of stress (Lazarus, 1991), thus inhibiting their experience of empowerment and increasing dropout rather

than encouraging adherence to participation in the activity (Hutzler, 1990; 2003; Hutzler & Bar-Eli, 1993; Hutzler & Sherrill, 1999).

A rigorous quasiexperimental design in conducting adaptation research is provided in an article by Karlyvas and Reid (2003). Objective participation criteria in a volleyball lead-up game (number of passes received and missed and time on and off task) as well as enjoyment (a motivational factor) were studied. Adaptations to this game included most categories represented in the SEMA model: (a) environment modification by reducing field dimensions and net height; (b) equipment modification through increasing and changing the mass of the ball and using a balloon instead of the original ball; and (c) changing rules relative to passing, touching, and serving the ball. Results indicated more successful passes (activity criteria) and more active time (participation criteria) in children with and without disabilities during the adapted compared to the nonadapted game. Findings also indicated, however, that older children without disabilities, ages 10-12, achieved higher in off-task behaviors in the adapted game and had a lower enjoyment level than did their younger peers with and without disabilities.

In summary, the current article described case reports demonstrating the use of a systematic model in designing, implementing, and studying effects of adaptations in different aspects of physical activity. Research comparing different types of adaptations is warranted in order to provide a more comprehensive evidence base for decision making. Case studies, single subject designs, and group designs, as well as reporting objective and subjective variables, including educators' and participants' perspectives on adaptations, are expected to provide more insight into this field of study.

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