Fundamental Movement Skills Assessment Tool:
A Validation Study of Balance Skills Using the Modified Delphi Method

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Abstract

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Background: Physical activity (PA) has a number of health benefits such as weight-control and prevention of lifestyle diseases. Fundamental Movement Skills (FMS) are important since they provide a base for PA participation. Injury prevention should be considered within a movement assessment because injuries are inevitable consequences of PA participation. However, current movement assessment tools do not account for injury prevention aspects. Practitioners often have a limited evaluation of movement patterns that is related to musculoskeletal injuries. There is a need for a more robust movement assessment tool that includes an injury prevention component. Balance should be incorporated into the assessment tool since it has been found to support the development of movement competence and has been linked to musculoskeletal injury prevention.

Objective: To establish face and content validity of balance skills (BSs) and the associated evaluation criteria, to create a FMS assessment tool to identify movement deficits while considering modifiable musculoskeletal injury risk factors.

Method: Using the modified Delphi method, a panel of experts completed three rounds of surveys to evaluate the suitability of the item using a 5-point Likert scale. Consensus on the acceptance of an item required 75% in agreement among the panel members. Descriptive statistics were used to analyze the data.

Results: Twenty-two of seventy invited experts (31.4%) participated. Twelve skills were initially proposed and the expert panel reached consensus on including three BSs (Single-leg side hop and hold, Two to one foot and hold, and 90-degree jump and hold) and twelve associated criteria.

Conclusion: This study provided face and content validity evidence for a FMS assessment tool for children 8-12 years of age. The modified Delphi process resulted in the final list of selected BSs which can be used for further research to evaluate the feasibility and reliability of the tool in various settings.

Keywords: Fundamental Movement Skills, Physical Literacy, Movement Competence, Balance, Physical Activity, Movement Assessment, Injury Prevention, Children, Delphi Method.

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Introduction

Theoretical Context

Physical Activity

Physical activity (PA) has a number of health benefits such as weight-control and prevention of lifestyle diseases.[1] Janssen *et al*.[2] and others[3-6] revealed that the likelihood of being overweight was significantly lower in children with higher PA participation in 29 countries. Another benefit that physical activity can bring to children is improved bone health.[7] The growing skeleton responds to the stress produced by weight-bearing PA, and increases in overall bone mass to adapt to the stress.[8] PA also positively affects mental health. Two recent systematic reviews of the literature on suggested that there is strong evidence to support the association between PA and mental health indicators such as anxiety, depression, and self-esteem.[9,10] Some studies suggested that PA is associated with academic achievement.[9,11] Despite this evidence, the health report of PA of Canadian children from 2007 to 2015 indicates that, fewer than 10% of children and youth have met 'the 60-minutes-per-day recommendation'[12] which is reflected in the rising number of obese children in Canada.[13] The percentage of children and adolescents with obesity aged 5-19 has dramatically increased from just 4% in 1975 to over 18% in 2016.[14] Thus, promotion of PA is vitally important for a child's overall health.

Physical Literacy, Fundamental Movement Skills, and Physical Activity

Physical literacy is "the motivation, confidence, physical competence, knowledge, and understanding of the value and responsibility of physical activity".[30] A child possessing physical literacy will have the capacity to carry out a wide range of physical activities, and under a variety of circumstances, with the confidence developed through the acquisition of proficient movement competence.[31] The correlation between movement competence, physical literacy, and PA participation can also be seen in the case of inadequate motor development, wherein physical literacy is stunted and there is a lack of engagement in PA.[32,33] Physical literacy encourages the inclusion of Fundamental Movement Skills (FMS) given the association between movement competence and recurrent PA participation which is vital for a healthy life.[32,34]

Fundamental Movement Skills (FMS), defined as "an organized series of basic movements that involve the combination of movement patterns of two or more body segments", [15] are considered to be the basic skills that lead to specialized movements.[16] FMS include locomotor skills such as running, hopping, skipping, and object control such as throwing, catching, and kicking.[15] In literature, FMS proficiency has been found to be significantly related to PA participation and negatively related to time spent in sedentary activities.[17-22] FMS proficiency in childhood is a significant predictor of subsequent engagement in adolescent physical activity.[23] Loprinzi *et al*.[24] suggested that FMS proficiency in children can increase their enjoyment of PA and thus increase the likelihood of participation in PA later in life. A child with higher FMS proficiency will tend to experience more enjoyment of the activity due to a perceived sense of capability. Lloyd *et al*.[25] investigated the potential long-term association of motor skill proficiency and PA in a 20-year follow-up study. In this study, the group with high childhood FMS proficiency showed higher PA in their adulthood than the group with low childhood FMS proficiency. Thus, developing FMS proficiency is important for participation in PA.

Importance of Fundamental Movement Skills Assessment and Balance Assessment

Acquirement of FMS proficiency can help children with application of the skills in different contexts such as sports and lifetime activities.[26] The association between FMS proficiency and PA participation becomes increasingly important in late childhood. In previous research, FMS and PA in preschoolers (3-5 years of age) was somewhat correlated but the association was weak.[21,27] On the other hand, Lopes *et al*.[17] believe that the level of FMS is strongly related to PA participation levels in older children (6-10 years of age). The results showed that children with good FMS maintained consistent levels of PA, while children with poor FMS showed a decline in PA as they aged. The relationship between PA level and FMS in children in Grade 8 (mean age, 13.3 years of age) and Grade 10 (mean age, 15.3 years of age) was seen to be stronger than that of young children.[20] The importance of FMS proficiency for PA participation in late childhood can be supported by a theory of motor development in childhood and adolescence. In early childhood (3 to 7 years of age), typically developing children establish their FMS (e.g. throwing, hopping) that provide the basis for later specialized movements (e.g. pitching, jumping-rope).[26] Children around 7 years old enter a "context-specific period" during which they actually apply their FMS elaborated into "building blocks" of specialized movements required for participation in PA.[26] For the passage into the context-specific period to occur, children require some opportunities for motivation, practice, and instruction in an environment that enhances learning, to break through a theoretical "proficiency barrier".[28] Failure to provide such opportunities will delay the application of their FMS to PA in this period.[29] Thus, the level of FMS proficiency that older children (8 to 12 years of age) acquired in early childhood can either accelerate or restrain development of skillfulness which is an essential component for a child's participation in PA.[26] As such, the assessment of FMS in older children, with the purpose of finding and correcting movement deficits, plays an important role in providing a firm base to build up their specialized movements. For that reason, there is a need to accurately assess movement competence FMS as an element of physical literacy, given the benefits that such an assessment can bring to the fields of health and education. If improved physical literacy results in PA participation, then the assessment of physical literacy becomes essential.[95] This assessment can also make positive contributions in improving the quality of physical education programs, in furthering existing assessments, and in the promotion of children's engagement in physical activities.[95,96]

Balance should be included in movement assessment due to its contribution to motor development and injury prevention. Rudd *et al*.[35], conducted a research to test construct validity of three stability movements. They used confirmatory factor analysis to verify if the three stability skills fit into the FMS model. Their finding revealed the BSs' theory is distinct and has influence on the development of test batteries and FMS assessment. Despite the relationship between FMS and balance ability, the results of the study[35] also suggested that children's stability skills cannot reach their full capacity simply by focusing on object control and locomotor skills. Therefore, BSs should be included in FMS assessment and balance ability needs to be assessed as a separate component within a FMS assessment tool.

Balance and Fundamental Movement Skills

Balance has been considered to support motor development.[35] Balance refers to one's ability to remain stable while carrying out work – which is known as dynamic balance, as well as one's ability to maintain overall stability while trying to remain still – known as static balance. Both are essential for motor development.[21,36] The earliest form of balance begins to emerge in young infants as they gain the ability to stand and then walk, usually beginning at 10 months of age.[37]

Forssberg[38] suggested that the commencement of independent walking in infancy is the result of the maturing postural control system (e.g. vestibular system). Whitall & Getchell[39] suggested that the onset of independent walking depends on the ability to keep balance in single-leg standing. Dynamic balance is required when it comes to performing locomotor skills. The ability to coordinate the limb movements while in a state of dynamic balance is demanded for children to perform locomotor skills. [40] For example, to propel the body forward during gait, children create the condition of a fall by leaning forward and then recover their balance with a step strategy. As a child's growth continues, the young person must adjust to a suddenly higher center of gravity. It is often associated with a decline in balance.[40] Butterfield & Loovis think that it is therefore conceivable that balance will reappear as a crucial element in skill performance for older children.[41] According to Liao & Hwang[47], this connection was examined in children with cerebral palsy (aged 5 to 12). Their results suggest a relationship between motor competency and static balance tests on a stable surface. Ulrich & Ulrich[48] conducted research to support the relationship between balance and FMS, where balance showed a significant relationship in the fields of hopping, jumping and striking. There have been some studies done to support a relationship between balance ability and kicking performance.[41,49,50] The research of Tracey *et al*.[49] shows a significant positive correlation between the balance score of a support leg (single-leg balance) and kicking accuracy. The positive relationship between both static and dynamic balance to kicking performance in 7th grade children was also revealed in a study done by Butterfield & Loovis.[41] Pistol and rifle shooting is a suitable example of how performance can be greatly affected by the most subtle changes in stability. [51-53] Thus, without balance ability, FMS or sport-specific skills are less likely to be performed well and development of FMS will be delayed when children lack balance ability.

Balance tests in current movement assessment tools for children

Some movement assessment tools for children (above 5 years of age) include some balance tests. The Movement Assessment Battery for Children 2nd addition (MABC-2)[82] consists of three balance tests including dynamic (Heel-raised walking, Heel to toe walking) and static (One leg balance, One-leg board standing, Two-leg board standing). The items in this movement battery are divided into three Age Bands (Age Band one: 3-6, Age Band two: 7-10, Age Band three: 11-16), each Age Band has a different level of difficulty. MABC-2 also measures one-leg hop and two-leg jump as a balance evaluation, yet it is more akin to locomotor skills since the participant does not pause during hoping or jumping. Bruininks-Oseretsky Test of Motor Proficiency 2nd edition(BOT-2)[83], designed to evaluate motor skills for children, contain balance tests very much alike with tests in MABC-2 (One-leg standing on the beam, heel to toe walking). Many other movement assessment instruments show similar trends of balance tests. Walking on the beam test is involved in the Basic Movement Competencies in fifth grade (MOBAK-5)[84] and *Koorperkoodinatoin test fur kinder* (KTK)[85]. MOBAK-5 uses a long see-saw bench with an obstacle on it. The bench seesaws when the participant moves to the other half of the bench. KTK involves a backward-walking on the beam test within different beam-widths. Eurofit Fitness Testing Battery[86] only includes one-leg standing balance (Flamingo balance).

Physical Literacy Assessment for Youth (PLAYfun)[155] is a physical literacy assessment tool which contains four balance tests which are heel-to-toe walking forward, heel-to-toe walking backward, drop to the ground and get back up, and lift and lower. Drop to the ground and get back up is a burpee kind of movement in which a child drops down on their stomach and stands up right away. Lift and low is performed by lifting a ball from the ground to above the head and lowering it back to the ground. Passport for Life[156] is another physical literacy assessment tool developed by Physical and Health Education Canada (PHE Canada). This tool includes one dynamic balance test 'lateral bound'. A child starts with single-leg standing. Then the child bounds laterally, lands on their opposite leg and, without pausing, bounds back to their original leg, holding the position for at least five seconds.

There are some balance assessment tools for children. Balance Error Scoring System (BESS)[87] provides a portable, low-cost, and objective assessment for static balance. BESS can be used to find balance deficit that is caused by mild head injury. This assessment assists clinicians in making "return to play-decisions" following the head injury. Balance tests in the assessment are: double-leg, single-leg, tandem stance with eyes closed. Tests are done on stable surface and on balance foam. Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB)[88] is used to evaluate a child's ability to maintain static balance in using different sensory inputs (visual, vestibular and somatosensory). The P-CTSIB consists of six sensory conditions: 1) eyes open, stable surface; 2) eyes closed, stable surface; 3) eyes open, wearing visual conflict dome, stable surface; 4) eyes open, balance foam; 5) eyes closed, balance foam; 6) eyes open, wearing visual conflict dome, balance foam. Each condition is performed with single-leg stance and tandem stance. Balance Evaluation System Test (BESTest)[89] identifies balance deficits in a wide range of different domains or systems of postural control. BESTest contain 36 items in six categories, classified according to different balance aspects: Biomechanical Constraints, Stability Limits/Verticality, Anticipatory Postural Adjustments, Postural Responses, Sensory Orientation, Stability in Gait. Franchignoni *et al*.[90] evaluated BESTest in using classical psychometric techniques and Rasch analysis to reduce its testing time and developed “Mini-BESTest” within a subset of 14 items (BESTest: It takes about 35mins to finish the whole process, Mini BESTest: it takes about 10-15mins). Star Excursion Balance Test (SEBT), primarily described by Gray[91], is used to assess dynamic postural-control deficit and as a predictor of low extremity injuries in research.[92,93] A subject squats down with one leg and reaches the free-leg as far as possible along the lines in eight different directions on the ground. Test-retest reliability of SEBT in primary school children was done in previous literature and the result showed moderate to good absolute agreement value and revealed that SEBT may be used to assess dynamic balance for children.[94]

Balance and Injury

Balance ability has been linked to high risk of injury.[54] Injury results when the tensile force applied to a structure is beyond its capacity to maintain it. Either the tensile force needs to be reduced, or else the structure’s ability to maintain the load must be improved to avoid or reduce the likelihood of injury.[55] Neuromuscular system is responsible for the simultaneous contraction of agonist and antagonist muscles that provides postural stability in response to the external perturbation and the changes in center of gravity. This mechanism also provides joint stability that can prevent joint displacement so that the strain on the structure is reduced.[56] Proprioception is a component of somatosensory system which detects body and limb position for the appropriate muscles to be contracted to position body segment properly. (e.g. appropriate feet position when landing from jump, steeping forward when pushed from behind).[57] This allows the joints to be protected from injury and can prevent falling.[58] Balance was often found to be an important factor of ankle injury. Researchers found that poor balance ability was significantly related to the number of ankle ligament injuries and individuals with poor balance showed an injury rate of two to seven times more likely to have an injury as compared those with good balance.[59-63] Additional studies suggest that balance training can reduce the risk of injury. Emery *et al*.[64] found that after the completion of a 6-week home-based balance-training program, subjects reported lower occurrences in all self-reported athletic injury over a 6 months period as compared to the control group. The results of previous research have also supported the effects of balance training intervention on the prevention of ankle sprains[65-67] and anterior cruciate ligament injuries[68]. Injuries are a reality in the practice of sports, although with the proper assessment, we can have a better understanding of the areas of movement in which those injuries are most likely to occur, and then develop methods to prevent them as much as possible.

Balance skills are included in many injury prevention programs (IPP) (**Table 1**). "FIFA 11+"[69] is an IPP developed by the Fédération Internationale de Football Association (FIFA). It is a complete warm-up program that contains fifteen exercises in core stability, balance and neuromuscular control, and agility and plyometric. The effect of FIFA 11+ on decrease in overall injury rate has been demonstrated in both male and female soccer players from adolescent to adult.[78-81] "FIFA 11+ Kids", also developed by FIFA, is designed for children 7-13 years of age, aiming to reduce injury risk factors.[70] The FIFA 11+ Kids considers specific characteristic of the age group and focuses on "1) spatial orientation, anticipation, and attention, particularly while dual-tasking; 2) body stability and movement coordination, and; 3) learning appropriate fall techniques".[70] Harmoknee[71] is another IPP specifically for soccer players. Harmoknee is a structured training program, performed within soccer practice sessions, which improves motion patterns and reduces strain on knee joints. The program includes five parts: warm-up, muscle activation, balance, strength, and core stability. Kiani *et a*l.[71] found that the inclusion of Harmoknee program intervention in the training session for nine months reduced 77% of knee injury incident rate and noncontact knee injury incident rate was 90% lower in the intervention group.

Core Stability and Balance

Core Stability (CS) has great influence in balance. The muscles for CS involve extensors (Erector Spinae, Latissimus Dorsi), flexors (Rectus Abdominis, Psoas, Transverse Abdominis), and rotators or lateral flexors (External Obliques, Internal Obliques, Quadratus Lumborum) of spinal motion and virtually all muscles between the shoulders and pelvis.[98] Akuthota *et al*.[99] described core muscles as "a muscular box" with the abdominal muscles (front), erector spinae muscles and gluteal muscles (back), the diaphragm (top), and the pelvic floor and hip girdle musculature in the bottom. Twenty-nine pairs of muscles in the “box” activate synergistically to stabilize the spine and pelvis to provide the postural control. The spine would lose its stability with a little additional weight beyond the weight of the upper body, without the support of the core muscles.[100] The loss of spinal stability will interfere with postural control,[97] and there is a positive relationship between CS and balance. Ten children who played badminton participated in 6-weeks CS training program significantly improved in Star Excursion Balance Test (SEBT) score compared with the control group.[112] Ghaeeni *et al*.[113] provided a 8-weeks CS training to children with down syndrome (8-13 years of age) and the CS training improved the static balance of the children. CS training programs were found to be effective in improving the balance of children with cerebral palsy.[114,115]

CS is also an important factor in many other ways, such as for sports-related performance[101,102], low extremity injuries[103], lower back pain[104], and physical fitness in a healthy individual[105,106]. Durall *et al*.[107] investigated the impact of trunk muscle training on occurrence of lower back pain in female gymnasts. The result revealed that there was a marked reduction of reports of lower back pain from athletes, coaches, and trainers during the subsequent gymnastics season in the core training group. In a literature review, Devlin[108] reported that fatigue of core stabilizer muscles cause inefficient running patterns and consequently increase risk of hamstring injury. The insufficiency of endurance, strength, and neuromuscular control of core muscles can be low-extremity injury risk factors.[109] CS can positively affect development of FMS for children. In the study by Bahram *et al*.[110], 15 elementary school children (7-10 years of age) who showed low proficiency of FMS, received 8-weeks of CS intervention. The result indicated that the intervention group improved significantly in all FMS performance in comparison with the control group. Similar results have been demonstrated in the research by Rostami & Ghaedi[111].

Research gap

It is important to promote PA participation for children considering that PA has several health benefits. However, all physical activities are associated with different levels of injury risk. According to the National Health Statistics Reports[157] in the USA, an average annual estimate of 8.6 million sports- and recreation-related injury incidents was reported from 2011 to 2014. The injury rate was especially higher in children 5-12 years of age. Half of the sport- and recreation-related injury incidents required treatment from a doctor. In Australia, three main causes for a visitation to an emergency department in children less than 14 years of age are related to physical activity such as sport and recreation, cycling and skateboarding, and playground use[158] and 14% of those events required a hospitalization.[159] Injuries such as non-contact anterior cruciate ligament (ACL) tears and ankle sprains are common lower extremity injuries during physical activity and sports. The mechanisms of those injuries in children are most often related with biomechanical injury risk factors; for instance, valgus knee (excessive hip internal rotation, hip adduction, knee abduction, and knee external rotation), excessively inverted foot during landing from a jump, quick decelerating, and sudden change of direction.[125] These uncontrolled lower extremity biomechanics are modifiable unlike non-modifiable risk factors such as sex, hormonal changes, and anatomical features,[130] and can be corrected by implementing specific training programs. The selection of the training program is aided by assessments in which modifiable injury risk factors can be identified. Thus, injury prevention aspect should be considered in any assessment in which children have opportunities to develop their motor competence. To our knowledge, no movement assessment tool for children includes the evaluation of movement deficits that are related to injury risk in physical activity. One approach that can be suggested is to incorporate injury prevention techniques derived from existing injury prevention programs, into motor competence assessments.

Some injury prevention programs (IPPs)[69-77] use "internal focus cues" to specify the movement patterns. Internal focus cues refer to "attentional focus on the performer's body motion, such as the arms, wrists, hips, etc. (e.g. keep your spine in neutral, keep your heels pointing forward, bend your knee to 90 degrees). External focus cues refer to "the environmental consequences made by the individual's body movements" (e.g. kick the ball as hard as you can, reach your hand to the cone, jump over the hurdle).[133] IPPs use internal focus cues to provide clear instructions of movement patterns that are required to reduce the risk of injuries and to enhance the performance. Internal focus cues are related to the quality of movement (movement pattern, body position) which can provide more information about modifiable injury risk factors. Nevertheless, many current movement assessment tools are missing the evaluation of movement components that are related to injury risk due to their focus on quantity of movements such as speed, distance, or success of the performance. When focusing on quantity of movement, it is still assumed that the subject who is able to score high, is capable of moving their body in the required manner regardless of movement quality.[124] For instance, a child who is able to perform a single-leg squat without losing his balance, may move in a different way from the way that is suggested to progress their skills and to prevent injuries. If the child cannot demonstrate components of a skill such as keeping their hips, knees, and ankles aligned straight during a squat, the child is considered to be at risk of injury. This may result from the absence of a standardized scoring system for FMS assessment that the examiner can use to find the movement deficits that may cause injuries or delay the development of context-specific skills. For example, in the case of Star Excursion Balance Test (SEBT)[91], the rater is asked to measure the maximum distance that the subject can reach with the free-leg while standing on a single-leg instead of screening the alignment of the knee and foot of the support leg and the upper body posture. A child who scores better than the others in SEBT may show excessive knee valgus which is considered to be a risk factor for the lower extremity. Application of the injury prevention techniques into FMS assessment may allow health professionals to evaluate the movement competence and, at the same time, contribute to the prevention of injuries in children. Injury prevention should not be ignored when assessing children's movement, and in fact, a proper assessment can serve to predict the risk of injury and limitations in particular movements.[134]

Assessment tools such as The Test of Gross Motor Development -2nd edition (TGMD-2)[110] and 'Get skilled Get Active'[15] use process-oriented measurement in which the quality of movement is assessed. Nevertheless, the evaluation criteria aim their attention only at motor competence and miss injury prevention prospects. For example, the evaluation criteria of 'single-leg hop', in TGMD-2 are: 1) non-support leg swings forward in pendula fashion to produce the force; 2) foot of non-support leg remains behind; 3) arms flexed and swing forward to produce the force; 4) takes off and lands three consecutive times on preferred foot; 5) takes off and lands three consecutive times on non-preferred foot. The techniques such as arm swing and leg swing are intended to enhance the performance (the hopping speed and distance). Contrarily, the instructions for ‘single-leg hop’ in FIFA 11^{+} kids[70] which is a well-known injury prevention warm-up program are: 1) hip, knee, and toes aligned; 2) knee and hip bend softly in a controlled fashion when landing; 3) toes pointing forward; 4) the left and right hips are at the same level; 5) the upper body is upright and in a central position. Body positions, especially lower extremity, such as knee alignment, hip drop, and landing techniques are emphasised in the program.

Another aspect of injury prevention for children that needs to be taken into account is fall prevention. Fall prevention is of great importance worldwide, considering that fall-related injuries can result in “the large amount of morbidity”, “the high costs of health care”, and “significant risk of death (from head injuries)”. Falls are the number one cause of all childhood injuries. Over 1800 children visit the Emergency Department each year in Waterloo Region alone due to injuries from falls.[121] McKinlay *et al*.[122] reported that falls are the leading cause of traumatic brain injury and 67% of traumatic brain injuries in children younger than 14 years of age are caused by falls. Falls ranked as the twelfth leading cause of death for children 5-9 years of age and approximately 47,000 children and adolescents younger than 20 years of age died as a consequence of falls in 2004.[123] Balance ability is associated with fall prevention and, especially, reactive postural control (RPC) is considered to be the primary component for fall prevention.[118] A deficit in RPC is a significant risk factor for prospective falls in children.[120] Sibley *et al*.[117] investigated the balance components evaluated in 21 pediatric movement assessment tools. The 21 pediatric movement assessment tools included 3-6 components but none of the assessment tools were found to evaluate RPC in the study. Deficiency of RPC is a major limitation of current assessment tools for children.

From all these consideration above, there is a need for a more robust FMS assessment tool for children that includes an injury prevention component.

Rationale

Participation in PA and sports has several health benefits such as disease prevention and physical ability improvement which is essential in maintaining a healthy lifestyle for children. FMS proficiency has a positive relationship with the level of PA participation. However, all physical activities are associated with different levels of injury risk.[157.158.159] Current assessment tools do not consider injury prevention due to focus on the performance (result-oriented assessment) in place of assessment of movement patterns (process-oriented assessment). A child's erroneous movements would be disregarded when using result-oriented measurements, especially when the child can score well, not because of an appropriate movement pattern but because of a high level of strength or speed. It is important to identify the potential injury risk factors since musculoskeletal injuries are inevitable consequences of PA participation and sports. An injury hinders children from engaging in PA, and as a negative outcome, could lead to a permanent physical disability. Balance is one of the three areas of FMS. There is a strong relationship between balance ability and musculoskeletal injuries.[54] Studies suggest that balance training can reduce the incident rate of lower extremity injuries.[64-67] Children need to acquire balance ability prior to the development of their FMS (locomotor skills and object control skills). Many existing movement assessment tools and the majority of IPPs include BSs. There is a need for an assessment tool that possesses a scoring system of the quality of movement (movement patterns) to assess FMS, incorporating the evaluation of potential injury risk factors. Balance should be included in the FMS assessment. IPPs use internal focus cues to reduce the risk of injury. Incorporating the preventative movement patterns into FMS assessment would be helpful to allow the evaluator to assess movement competence while identifying higher risk movements that are generally associated with injuries.

Objective

The objective of this study was to establish face and content validity of balance skills using the modified Delphi method. We aimed to establish consensus among an expert panel on selection of four balance skills with a minimum of four associated evaluation criteria. The skills and criteria will be included in the FMS assessment tool for children 8-12 years of age. The tool is intended to assess motor competence and to identify modifiable musculoskeletal injury risk factors.

Hypotheses

1. Face and content validity can be established on four balance skills. These skills will be included in the FMS assessment tool to assess motor competence and to identify modifiable musculoskeletal injury risk factor for children 8-12 years of age

2. The face and content validity can be established on four evaluation criteria associated to each balance skill identified in hypothesis one. These criteria will be included in the FMS assessment tool to assess motor competence and to identify modifiable musculoskeletal injury risk factor for children 8-12 years of age

Method

We asked for the ethics approval on May 28th in 2018 and received the Certification of Ethical Acceptability for Research Involving Human Subjects (certification number: 30004928) from the University Human Research Ethics Committee of Concordia University on September 18th in 2018.

The modified Delphi method

We used the modified Delphi method to test content validity of balance assessment movements for children 8-12 years of age. The Delphi method is "an iterative process to collect and distill the anonymous judgments of experts using a series of data collection and analysis techniques interspersed with feedback".[135] In this method, a group of experts forming the "Delphi panel" respond to a questionnaire created by the researcher in each iteration (round) to share their opinions. The researcher collated the data from the Delphi panel to generate a questionnaire for the next round. The researcher sent the next questionnaire with feedback from the results of the previous round. A three-round method is generally used, but the round can be continued until a consensus among the Delphi panel members is reached.[136] The Delphi method was originally developed to compensate for the deficits of a face to face discussion. The conversation in a discussion can be controlled by certain dominant individuals, not because they are the most knowledgeable ones but because they speak out while others fear to be criticised then hesitate to express their opinions.[136] The result reached through face to face discussion is often less accurate than averaging the opinions of individuals collected separately.[137] The Delphi method is typically applicable when there is no clear evidence for a specific topic. It is a flexible, cost-effective, and simple way to share knowledge without interpersonal pressure and geographical limitations.[136] The Delphi method was previously used to validate assessment tools for physical activity[138-140] and health care[141].

The difference with the modified Delphi method is that the researcher typically does not consult the expert panel to provide the initial items in the first round rather the researcher collects the items prior to the Delphi process. With the conventional Delphi method, the first round is aimed to ask the expert panel to list the items that will be included in the next round survey. The advantage of using the modified Delphi method is that the expert panel can skip the initial process and begin with the consensus-seeking process. The researcher can collect the initial items in several ways: 1) derive the items from literature review; 2) the researcher can have a series of interview either within or outside of the expert panel; 3) the researcher can conduct a survey outside of the expert panel

Recruitment of Delphi panel

It is recommended that the selection of a representative sample be avoided in the Delphi method since the Delphi panel does not have to represent a population. Therefore, non-probability sampling (convenience sampling, snowball sampling) was used to recruit the experts to form the Delphi panel. Lynn[142] suggested that five to ten experts are considered to be sufficient for content validation. Ludwig[143] reported that the majority of Delphi studies have used between fifteen and twenty participants.

We used the Knowledge Resource Nomination Worksheet (KRNW)[144] to identify the experts, and to categorize the experts to avoid overlooking any important classification.[144] The procedure for selecting the experts was: 1) determined the classification such as discipline, skills, literature, and organisation, which are relevant to the research topic; 2) recorded names of potential experts found in the each classification; 3) created sub-lists for each discipline and categorized the experts according to the lists. The experts were ranked in each discipline based on their qualifications; 4) invited experts by sending an e-mail in the order of their ranking in each discipline until the sample size was reached.[144] Additional recruitments were conducted in case the number of experts did not reach the target number ($n \geq 10$). The selected experts had at least one of the following criteria: 1) being involved in research on the use of assessment tools for either children's' movements or injury prevention; 2) being a (co-) author of one or more published articles about children's movement assessment tools, FMS, or injury prevention; 3) being a lecturer in a health-related program, such as kinesiology, exercise science, physical therapy, and athletic therapy, at a recognized academic institution; 4) being involved in developing an assessment tool related to FMS or injury prevention; 5) working directly with children's movement assessment tools, FMS, injury prevention.[146] The experts needed to be willing to participate in the process and have enough time to answer the surveys appropriately.[144]

The Delphi panel members

A total of fifty-three international experts were identified by KRNW and invited in the first round. Fourteen experts participated and ten experts declined to participate in the first round. After the first round, fourteen experts including the experts who declined were removed from the invitation list and seventeen experts were newly identified, added to the invitation list. A total of fifty-six experts were invited and fourteen of them participated in the second round. All of the experts who participated in the first round or/and the second round were invited in the third round. A total of fifteen experts participated in the third round. Overall, a total of seventy experts were invited and twenty-two experts participated.

Procedure

Prior to the Delphi process, a pilot study was performed outside of the expert panel (n=4) to verify if any modification was needed. In all three rounds of the Delphi process, the invitation was sent by e-mail and a reminder was sent to the experts who did not begin nor refuse. The invitation contained the information about the aim of the study, their role in the study, the estimated amount of time they were expected to contribute, and what the procedure was. After reading the invitations, the experts were asked to click a link included in the invitation e-mail that led to the survey in case they were willing to continue. To express their refusal to participate in the study, they were asked to click another link that sent a notification to the researchers. The surveys were created and completed using 'LimeSurvey'[151] which is an on-line statistical survey tool.

First round

In the first round survey, the participants were asked to: 1) answer if the balance skills (BSs) should be included in the FMS assessment tool; 2) answer if the evaluation criteria for each skill should be included in the FMS assessment tool; 3) suggest any BS or criteria that should be included; 4) make any comments in regard to the items or the study in general. The participants scored each item using a 5-point Likert scale:[139] 1) strongly agree; 2) agree; 3) neutral; 4) disagree; 5) strongly disagree. Selecting 1) or 2) was considered to be in agreement on including an item and selecting 3), 4) or 5) was considered to be in disagreement. A consensus was reached with 75% agreement and an item was removed with 75% disagreement.[138] When an item was neither accepted to be in the third round nor was removed, the item was moved to the second round to be scored again. The BSs and criteria suggested were filtered and the selected items were added in the second round survey.

Second round

Feedback based on the result of the first round was provided within the survey. The feedback included: 1) the list of items that achieved consensus in the first round; 2) the percentage of agreement for items on which the experts did not reach consensus; 3) the list of new items that were added with suggestions made in the first round; 4) any noticeable changes made after the first round. In the second round survey, the participants scored the items on which a consensus was not achieved and the new items that were added with suggestions. The participants were asked to: 1) answer if the BSs should be included in the FMS assessment tool; 2) answer if the criteria for each skill should be included in the FMS assessment tool; 3) make any comments in regard to the items or the study in general. The scoring method was the same as the first round survey. The inclusion criteria to be in the third round were: 1) the items must achieve consensus; 2) the BSs must have four or more criteria that achieve consensus; 3) the criteria must be associated to a BS that is included in the third round.

Third round

Feedback based on the result of the second round was provided within the third round survey. The feedback included: 1) the list of BSs that achieved consensus through the previous rounds; 2) the list of criteria that achieved consensus through the previous rounds. The items were ranked in order of importance for FMS assessment and injury prevention techniques according to the experts' judgements. The top four BSs and top four criteria for each BS in the final ranking were selected to be included in the FMS assessment tool.

Statistical Analysis

A descriptive statistic was used to analyze the data produced by a 5-point Likert scale. A consensus was reached with 75% agreement (defined in the percentage of responses with 'agree' or 'strongly agree'). Inverted point values[136] were assigned to rank the items. For example, the item ranked as the most important among ten items was assigned ten points and the item ranked in last place was assigned one point. The final ranking was made in order of the sum of the points.

Results

Twenty-two of an overall seventy invited experts participated (31.4%). **Table 2** shows the characteristics of the experts who participated in this study. The most common primary field of expertise for the expert panel was athletic therapy/training (31.8%) followed by motor development (18.2%) with professor (27.3%) as the most common primary affiliation (**Table 3**). The expertise of Delphi panel were also categorised by two main areas of this study, injury prevention and motor competence. There were more experts in injury prevention (59.1%) than motor competence (40.9%) in total and in all three rounds. More than half of the experts had a doctorate (54.5%) and were from Canada (59.1). The location of the participants included U.S.A (18.2%), U.K (13.6%), Australia (4.5%), and Switzerland (4.5%). All participants read and agreed to the terms listed in the consent form included in the first round survey.

A total of twelve BSs were derived from literature (**Table 4**) and a total of ninety-six items (twelve BSs and seven criteria for each skill) were scored and ranked by the expert panel through the Delphi process. Three BSs (Single-Leg Sideways Hop and Hold (100%), Two to One-foot Hop and Hold (78.6%), 90 degree jump and hold (78.6%)) and four criteria for the three BSs were accepted to be included in the FMS assessment tool. Single-leg balance eyes closed has achieved consensus among the experts. However, this skill has not been accepted due to insufficient number of its evaluation criteria. A total of 172 comments were made to suggest any skills and/or criteria that the experts believe are important and to give any opinion related to the items. The study flow of all three rounds including the number of experts and their responses are summarized in **Figure 1.**

First round

Fifty-three experts were selected using Knowledge Resource Nomination[144] and invited to be a member of the Delphi expert panel. Fourteen of fifty three invited experts (26.4%) participated in the first round while ten experts expressed their refusal and the rest did not respond to the invitation. The first round Delphi panel consisted of injury prevention experts (57.1%) and six motor competence experts (42.9%). The first round survey included ninety-six items (twelve BSs and eighty-four criteria) and the experts scored each item. See **APPENDIX** to find the examples of the content of the surveys for all three rounds.

First round outcomes

See **Table 5** for the percentage of agreement on BSs through the first round and the second round. Two BSs (Single-leg balance eyes closed: 92.3%; Two to one-foot hop and hold: 78.6%) and twenty-four criteria achieved consensus among the experts. Despite a high level of agreement (71.4%), 'single-leg sideways hop and hold', '90-degree jump and hold', and 'single-leg stance on unstable surface' failed to achieve consensus in the first round. The criterion 'foot flat on the floor (or on the balance pad) was associated with nine BSs and achieved consensus in all nine BSs. On the other hand, 'keep your hands on your hips' (associated to nine BSs) and 'keep your chest up' (associated to six BSs) failed to achieve consensus in all skills.

The experts made a total of 128 comments. The experts made fifteen comments for single-leg Romanian deadlift and fourteen comments were made for single-leg balance eyes closed and single-leg squat. Eight comments suggested some movement skills to be included in the FMS assessment tool. Two experts recommended considering 'object control skills' such as throwing, kicking, and striking. Two core stabilization skills (front plank, side plank) were suggested as well as three upper body control skills (push variations, pull-up, and overhead reaching). The experts advised to use some variations on front plank and side plank to have a process-oriented measurement since the outcome of basic plank is usually a time. The Y-balance test was also proposed. Several comments implied that the experts did not clearly understand how some BSs are performed. For instance, an expert advised that it would be difficult to assess the performance of 90-degree jump. The intention of the skill '90-degree jump and hold' is to see how a child lands and keeps their balance after a 90-degree jump; how the child jumps is less important.

Eighty criteria were suggested in the first round. Among the suggestion for criteria, position of foot (and toes) was mentioned the most with nineteen times followed by knee position and stillness in position with seventeen times and eight criteria about chest position were suggested. Forty comments were made to give some feedback for the skills and the study in general. Some experts expressed their confusion with the term 'internal focus cues'. The criteria were made in a form of internal focus cues and were called ‘internal focus cues’ (e.g. keep your head up, bend your knees) in this round. The experts mentioned that they were not certain whether the criteria (which were called ‘internal focus cues’) were used as instructive cues or as criteria since the internal focus cues are, in general, used to give an instruction of a movement.

Second round survey creation

Second round survey was created based on the responses in the first round. Ninety-one items were included in the second round survey. The ninety-one items include 1) ten BSs and fifty-two criteria from the first round survey; 2) two new BSs (front plank and side plank) with fourteen associated criteria (based on suggestions in the first round); 3) thirteen new criteria (based on suggestions in the first round).

Front plank and side plank were added as ‘core stabilization skill’ which is incorporated in this study due to its relationship with balance ability. As a result of the comment (in the first round) that advised to use variations on two core stabilization skills, we decided to use ‘single-leg front plank’ and ‘side plank with arm reaching upward’. The rest of the suggested skills were eliminated for the following reasons. All upper body skills (push variations, pull-up, and overhead reaching) were removed since the skills do not accord with the aim of this study in which the focus is on lower extremity injury risk factors. The Y-balance test is commonly used for children’s balance. The test is generally used as a product-oriented test in which the outcome is the distance that a subject can reach out with their foot as far as possible. Again, it is not in agreement with the purpose of this study as we aim to create a process-oriented assessment tool. Additionally, the Y-balance test is biomechanically similar to the single-leg squat which is one of the twelve BSs proposed at the beginning.[152] The thirteen new criteria consisted of 1) eight criteria that were selected among the criteria suggested in the first round; 2) five criteria were created by combining two criteria (in the first round) into one criterion (See **Table 5** for the detail). The rest of the criteria suggested in the first round were not selected as a result of overlap with existing criteria. The term ‘internal focus cues’ was removed and the criteria were reworded to be clearer on their purpose. For instance, ‘keep your toes pointing forward’ is an imperative sentence that could be misunderstood as an instructive cue; thus, it was reworded to ‘toes pointing forward’. (**Table 5)** Based on the comments from the experts in the first round, we found that the word ‘deadlift’ in ‘single-leg Romanian deadlift’ gave an impression that this skill is a resistance exercise since the skill is usually done with some extra weight. This skill was included in this study to assess the hinge movement pattern. Therefore, single-leg Romanian deadlift was renamed as 'single-leg hip hinge’. As a result of the comments the descriptions of BSs were modified to be clearer on their purposes (**Table 6**).

The feedback was provided within the survey. The percentage of agreement in the first round was indicated beside each item. (e.g. single-leg squat (64.3%), hands on hips (45%)). The items that achieved consensus in the first round were colored green and the experts did not score these items. Any changes made after the first round were given to the experts prior to starting the second round survey.

Second round

The second round survey invitation was sent to fifty-six experts including the fourteen participants in the first round, twenty-five experts who were invited in the first round but did not respond, and seventeen newly identified experts. Fourteen experts were removed from the invitation list after the first round (ten experts declined to participate in the first round and four experts were replaced by newly identified experts with the same expertise). A total of fourteen experts participated in the second round (25%). The second round Delphi panel consisted of ten injury prevention experts (71.4%) and four motor competence experts (28.6%).

Second round outcomes

The expert panel scored ninety-one items and reached consensus on two BSs (90-degree jump and hold (78.6%), single-leg sideways hop and hold (100%)) and thirty-nine criteria. Both of the BSs had 71.4% agreement in the previous round. Single-leg balance on unstable surface also had 71.4% agreement in the first round yet; the percentage remained the same in the second round. The figure for the BSs stayed similar to the first round (less than ± 7.2%) while ‘alternate knee-up and hold on unstable surface’ jumped from 23.4% to 64.3% and ‘step-up and hold on unstable surface’ dropped from 41.7% to 21.4%. ‘Single-leg hip hinge’ and ‘single-leg front plank’ had more criteria that achieved consensus than the other BSs but the skills themselves were rejected.

A total of forty-four comments were made to give the experts' opinions on the items. The experts argued that some of the BSs proposed were not considered as fundamental movement skills (side plank, single-leg front plank, single-leg hip hinge, alternate knee-up and hold on unstable surface) and those skills are rather considered as functional skills or fitness test. Some comments suggested that some of the BSs might be too difficult for children 8-12 years of age (single-leg squat, bird-dog exercise).

Through the two rounds, the experts reached consensus on four BSs and sixty-three criteria. Four or more criteria achieved consensus for 'Two to one-foot hop and hold (four criteria)', 'single-leg sideways hold and hold (four criteria)', and '90-degree jump and hold (six criteria)' therefore, these skills met the inclusion criteria to be in the third round (≥ four criteria). However, 'single-leg balance eyes closed' was rejected as only three criteria achieved consensus on the skill.

Third round

In this round, only the experts who completed at least one survey were eligible to participate since the experts were required to have the understanding of the general concept of the study and all the skills that have been scored. Thus, twenty-two participants in the previous rounds were invited and fifteen of them participated (68.2%). A total of seventeen items were included in this round: 1) two to one-foot hop and hold (TOHH) with four criteria; 2) single-leg sideways hop and hold (SSHH) with four criteria; 3) 90-degree jump and hold (90JH) with six criteria.

Third round outcomes

The items were ranked in order of importance for FMS assessment and injury prevention techniques to select four BSs and four criteria for each skill. BSs were ranked with locomotor skills. Locomotor skills were not included in this study but they are part of the FMS assessment tool and were involved in another study. TOHH was ranked 7th out of ten skills followed by SSHH (8th) and 90JH was ranked in the last place (10th). Regardless of this result of the ranking, the all three BSs were included in the FMS assessment tool as we aim to include at least four BSs. Moreover, two BSs (TOHH, SSHH) had only four criteria, for that reason, the experts did not rank the criteria for those skills. Six criteria for 90JH were ranked and the ranking was in order of:

1) Knee and hip bend slightly to land softly in a controlled fashion; 2) Knee and toes aligned; 3) Whole body turns together; 4) Toes pointing forward; 5) Foot flat on the floor; 6) Stand up straight within three seconds after landing. The top four criteria were selected according to the ranking and 'foot flat on the floor', 'stand up straight within three seconds after landing' were rejected (**Table 7**).

Thus, the modified Delphi process resulted in the final fifteen items that will be included in the FMS assessment tool for children 8-12 years of age. The fifteen items consist of 1) three BSs (Two to one-foot hold and hold, Single-leg sideways hop and hold, 90-degree jump and hold); 2) twelve evaluation criteria associated to the three BSs (four criteria for each skill) (**Table 8**).

Discussion

The Delphi panel

This study aimed to establish the content and the face validity of BSs to create a FMS assessment tool using the modified Delphi method. A total of seventy international experts were invited and twenty-two experts participated in the Delphi panel. The number of experts amounted to fourteen both in the first and the second round and fifteen experts participated in the third round. Lynn[142] suggested that five to ten experts are considered to be sufficient for content validation. Ludwig[143] reported that the majority of Delphi studies have used between fifteen and twenty participants.

The expertise of the Delphi panel

Two main areas of expertise (motor competence and injury prevention) are included in this study. The experts made contributions in both areas through all three rounds despite the proportion of the experts being uneven. There were more injury prevention experts (injury prevention experts: 59.1% motor competence experts: 40.9%) probably because more experts in this area were identified and invited intentionally due to the injury prevention aspect emphasis in this study. The objective was to integrate injury prevention into FMS assessment. Some of the skills (including locomotor skills that were addressed in another study) were considered valid as a motor competence assessment skill, but it was unclear that those skills could be used to assess motor competence and identify modifiable injury risk factors. For that reason, guaranteeing a sufficient contribution from injury prevention experts was an important condition required to achieve the study objective.

Response rate

The overall response rate was 31.8% (22/70). Susan *et al*.[116] suggests that results of a survey may be compromised when the response rate is less than 80%. Sumsion[119] indicated the lower response rate of 70% is required in each round to maintain the Delphi process rigorous. The response rate in this study is considered low. Low response rate is a factor that may jeopardize the validity of the results by increasing ‘non-respondent bias’.[126] The likelihood of non-respondent bias occurring can be increased when the characteristics of respondents and that of non-respondents are significantly different. The significant difference between two groups (respondents and non-respondents) can imply that the survey is favoured by a particular population most interested in the survey subject therefore the results are more likely to be biased. In other words, if the non-respondents have the same or similar characteristics with the respondents, the response rate might not be a major consideration.[126] Kellerman & Herold[128] suggested that the non-respondents bias is unlikely to occur when a survey is conducted to a group of experts in the same or similar disciplines. The experts who were invited in this study possess the same or similar expertise and they were chosen by particular criteria thus, are considered more homogenous than general population.[128] Despite variations that still exist among the experts, the variations may not affect the willingness to respond as in the general population.[128] As long as the number of the Delphi panel member is sufficient and the panel members possess the expertise required in the study, the value of the response from each member is appreciated therefore, the validity of the results is protected.

Another theory that can be taken into consideration to interpret the low response rate is that the figure may not be the true response rate.[131] When an expert does not respond, the truth whether the expert was not willing to participate or the e-mail was not delivered remains unknown. In this study, the experts were asked to choose to continue the survey or decline by clicking 'Yes' or 'No'. Only thirteen experts declined or replied to express their refusal through the Delphi process in which the intention of the rest of experts (n=34) were unrevealed. If the experts did not respond unintentionally, the non-respondents bias would not be applicable.

Balance skills accepted

Among the twelve balance skills (BSs) initially proposed, Single-leg Sideways Hop and Hold (SSHH), Two to One-foot Hop and Hold (TOHH), and 90-degree Jump and Hold (90JH) were accepted to be included in the FMS assessment tool with four criteria associated to each BS. Interestingly, all three BSs accepted include 'jump (hop) and landing to stabilization' component. Those three skills were selected from literature review at the beginning because of the landing to stabilization component. In these skills, we focus more on the movement quality of landing and stabilization after landing than on hopping or jumping itself. Landing technique is an essential aspect in many physical activities and is widely used in injury prevention programs (IPPs) and assessment tools due to its relationship with lower extremity injuries.[69,70,72,74,75,129,156] The experts were doubtless aware of the importance of landing technique and that emerged as the results. This outcome may have been influenced by the expertise of the participants. Almost 60% (57.1%) participants were injury prevention experts in the first round and the percentage increased to 71.4% in the second round. The disagreement response rate for SSHH, TOHH, and 90JH (the percentage of the responses for 'neutral', 'disagree', and 'strongly disagree' out of all responses for the three skills) was 9.1% in the injury prevention group while the figure was 30% in the motor competence group. It may be because landing to stabilization is more prevalent in IPPs than in motor competence (physical literacy) assessments. Among the motor competence assessment tools that are commonly used for children such as Movement-ABC-2[82], KTK[85], TGMD-2[110], Passport for Life[156], and PLAYfun[155], only Passport for life includes landing to stabilization while many IPPs and injury prevention assessments include this element. [69,70,72,74,75,129,130,153,156] Therefore, the three BSs may have been preferred by the injury prevention experts and the higher proportion of injury prevention experts may have favored the acceptance of the three BSs.

Comparison of Single-leg Sideways Hop and Hold and Two to One-foot Hop and Hold

The three BSs assess the same component (landing to stabilization) still, they are different. Perhaps, one can be more suitable to assess dynamic balance than the others or all three BSs need to be assessed because each skill has a unique characteristic. There is no study that compared the three BSs directly nonetheless, several studies compared the landings from different directions in which the comparison can be made indirectly. In the study by Sinsurin *et al*.[43], peak knee valgus angle during the landing phase was compared among four directions (forward, 30° diagonal, 60° diagonal, and lateral). The peak knee valgus angle while landing on one leg from the lateral jump was significantly higher than the forward jump. Higher peak knee valgus angle can increase the risk of lower extremity injuries.[43] Moreover, landing from the lateral jump showed more signs of stiff landing including higher peak dorsiflex angle, lower peak knee flexion, and lower peak hip flexion in landing phase than landing from forward jump and the participants in the study expressed that landing from the lateral jump was most difficult among the four directions.[44] Similar results were shown in the study by Taylor *et al*.[42] who examined the differences on the lower extremity biomechanics between forward jump-landing and lateral jump-landing. The participants were asked to perform the two jumps task on both single-leg and double-leg. The results revealed that landing from the lateral single-leg jump showed more predominant signs of dynamic knee valgus including hip adduction, hip internal rotation, knee abduction, and knee external rotation moments. The authors suggested that the double-leg forward jump-lading does not represent the biomechanical demands in multi directional sports therefore single-leg lateral jump-landing may be included in an assessment to identify high risk injury risk factors. More signs of lower extremity injury risk that were seen in the lateral jump-landing than the forward jump-landing may be due to postural characteristics of the lateral jump-landing. According to Dempsey *et al*.[164], the sideways cuttings with the trunk leaning towards to the support leg and the foot positioned farther on the opposite side of the cutting direction increased peak valgus moments significantly compared to normal sideways cutting. Lateral trunk flexing toward the support leg is likely to increase hip adduction moments which may move the knee medially hence knee abduction moments can be increased.[165] Hip adduction and knee abduction moments are contributors of dynamic valgus moments. Similar posture can be seen in SSHH. Using an example of SSHH to the right, the right foot which is the landing foot will lead towards the direction of travelling followed by upper body. At the initial contact to the ground, the right foot will locate far from the midline that passes center of mass perpendicularly, on the opposite side (right side) of the trunk. At that moment, the hip strategy (trunk lateral flexing to the right) will need to appear to move the center of mass over the base of support. In literature, lateral trunk flexion towards the landing leg was seen and had a positive relationship with knee abduction moments during the lateral jump-landing task.[166]

The jumping direction can also influence the postural control after landing. Study by Wikstrom *et al*.[45] compared dynamic postural stability index on different directions of jump-landing. They defined dynamic postural stability index is a composite score of anteroposterior, mediolateral, and vertical ground reaction forces, and determined that a higher score indicates worse postural control.[45] They reported that the lateral jump-landing showed significantly higher score on medial/lateral stability index than the other directions (forward and diagonal) which implicate that the participants were less successful to maintain balance in the lateral jump-landing task. Previous work by Liu & Heise[46] had similar results, and indicated an increase of medial/lateral time to stabilization, equivalent of medial/lateral stability index, in the lateral jump-landing and also an increase of anterior/posterior time to stabilization in the forward jump-landing. Based on literature, SSHH (lateral jump-landing) appears to require higher level of dynamic balance and children may expose lower extremity injury risk factors (e.g. dynamic knee valgus) more in SSHH than in TOHH (forward jump-landing). However, it is not clear if the results are reproducible in children population since the participants in the literature were mostly adult population. TOHH might be less demanding according to the literature, but it provides a different stimulation that may identify modifiable injury risk factors or balance deficits that the rater may not identify in SSHH and 90JH. In addition, single-leg forward jump-landing is a movement most commonly seen in multi-directional sports such as netball.[160] It was strongly suggested that multiple directions of jump-landing should be incorporated into assessment of dynamic balance.[46]

90-Degree Jump and Hold

The 90-Degree Jump and Hold (90JH) is performed differently than the SSHH and TOHH. The 90JH is a vertical jump combined with a whole body rotation. Despite the vertical direction, horizontal forces (coupling force of medial-lateral and anterior-posterior) need to be generated at the ground to produce an angular momentum for an airborne rotation in a rotational jump.[161] In turn, horizontal Ground Reaction Force (GRF) is required to stop the rotation[163] and this force will influence a controlled landing followed by the stabilization. Rotational jump is often seen in various sports and failure of the proper landing may delay performing the subsequent movement.[160,163] A rotation while airborne is considered to affect lower extremity biomechanics during landing phase.[164,167,168] A trunk rotation towards the support leg is shown to increased internal rotation of knee joint in sidestep cutting task[164] and increase valgus moments during single-leg landing from overhead catching task[168]. The effects of trunk rotation on lower extremity biomechanics in double-leg landing showed a similar response.[167] The leg ipsilateral to the trunk rotation (e.g. the right leg when trunk is rotated to the right) demonstrated less knee flexion angle and higher knee abduction angle, knee internal rotation angle, and vertical GRF than the contralateral leg. However, double-leg landing from a whole body rotational jump (without separate trunk rotation) produced results diametric to the jump-landing with trunk rotation in all variables measured.[167] This may be because the whole body rotational jump was performed in combination with forward jump in the study (e.g. the participants jumped forward, rotated 90-degree while airborne and landed laterally). Therefore the leg contralateral to the rotation in the whole body rotation jump-double leg landing experienced a situation similar with the lateral leg in lateral jump-landing task (e.g. right leg when performing lateral jump to the right and land with the right leg). This phenomena is supported by literature in which double-leg lateral jump-landing showed less in knee flexion and higher in knee abduction and hip internal rotation than double-leg forward jump-landing.[42] It is not clear from literature how the biomechanical features would appear during 90JH (a single-leg rotational jump-landing that is performed vertically without horizontal displacement). A possible scenario of the landing phase of 90JH based on the literature can be predicted. As explained above, the angular momentum is generated to produce the whole body rotation while airborne. When landing, the body will continue rotating by inertia force while the landing foot is stopped by GRF and fixed on the ground. This may induce a twisting of the lower extremity joints therefore foot medial rotation (toe-in), knee internal rotation, and hip internal rotation might be increased. These biomechanical characteristics have been seen in landing with trunk rotation towards the landing leg,[164,168] thus it is possible that 90JH would produce similar results. The jump-landing with trunk rotation towards the support leg can give more distinct signs of knee valgus and knee internal rotation than the jump-landing without rotation jump. Therefore 90JH in which a child is asked to rotate towards the support leg may be more advantageous to identify modifiable injury risk factors than a simple vertical jump-landing or a jump-landing with a rotation in the opposite direction.

It is unclear that which of the three landing to stabilization skills is best for the assessment of dynamic balance and for identification of modifiable injury risk factors. The BSs accepted are considered to assess the same components of balance assessments categorised by Sibley *et al.*[117] (dynamic balance, anticipatory postural control). Nevertheless, this categorisation may not include all aspects involved in the postural control. De Kegel *et al.*[179] suggested that balance cannot be tested in a single test. Balance is multidimensional concept and does not rely on a single system such as somatosensory system. Different motor, sensory, and cognitive systems collaborate to provide postural stability according to a specific situation. Task- and context-specific requirements make each balance test unique even when the tests are considered to assess the same component of balance assessment. Thus, it may be more beneficial to include all three BSs. Moreover, many sports involve multi-directional activities including jump-landings in different directions and in different situations. [160,163]

Evaluation criteria

A total of four evaluation criteria are associated to each skill in this study. There is a similarity in the combination of the criteria for each of three BSs. Two criteria ‘knee and hip bend slightly to land softly in a controlled fashion’ and ‘knees and toes aligned’ were accepted for all the three skills and two other criteria ‘foot flat on the floor’ and ‘toes pointing forward’ were accepted in two of the three BSs. (**Table 8**). This results in which the criteria were accepted for two or all three BSs can implicate the importance of the criteria for the assessment of landing-stabilization component. The criteria accepted are essential to assess balance and to identify injury risk factor thus assessing the criteria in different skills can increase the chance to find the problematic movement pattern that is related to poor balance or lower injury risk factors.

Three criteria ‘knee and hip bend slightly to land softly in a controlled fashion ’, ‘knees and toes aligned’, and ‘toes pointing forward’ are techniques (soft landing, lower body alignment, foot position) that influence the lower body biomechanics and possibly reduce lower extremity injury risk.[169,170,171,176,177] The results of the Pollard *et al*[171] study demonstrated that the subjects who performed a drop-landing task using a stiff landing showed greater frontal plane loading at the knee joint such as knee valgus angle, knee adduction moment. Lower body malalignment such as knee valgus is considered as risk factor for ACL injuries.[171] Literature suggested that 23% less impact was generated in soft landing, described as a landing with an adequate knee and hip flexion.[170] Of the 23%, 19% of the energy absorbed during soft landing was as a result of a contribution from knee and hip extensor muscles,[170] indicating the importance of eccentric contraction as deceleration of the body during landing. Since the lower extremity acts as a kinematic chain, foot position can influence the motions of the other segments of lower body. The criterion ‘toes pointing forward’ was initially proposed as a result of its relationship with the lower body biomechanics. Landing in the toe-in position is considered to be a risk factor for ankle lateral sprains.[176] Landing in the toe-in position was also found to increase the risk for ACL injuries including peak hip adduction angle, peak knee internal rotation angle and moments, and peak knee abduction angle.[177] It was also revealed that the toe-in landing decreased peak knee flexion and hip flexion which are the signs of stiff landing.[177] Ishida found similar results.[178] The toe-in landing significantly increased peak knee internal rotation angle and peak knee abduction angle and moments.[178] This criterion (toes pointing forward) was not accepted for SSHH.

Literature in which the foot position significantly influenced the lower body biomechanics used a forward drop jump-landing task.[176,177,178] On the other hand, the toe-in and the toe-out position did not have a significant effect on knee valgus angle during sideways cutting[164] which is similar with SSHH in terms of biomechanics thus, based on the literature, landing with toe out may not greatly increase ACL injury risk in SSHH as it might with TOHH. 'Foot flat on the floor' is a technique to maximize the range of base of support which is defined as the part of the body that contacts the surface of supporting. (e.g. the sole of the support leg in a single-leg stance). The state of equilibrium can be accomplished when center of gravity stays vertically within the range of base of support, in other words, it is easier to maintain balance when the base of support is wider. The landing foot that remains full contact with the floor will provide a maximized range of the base of support in the landing phase and the following single-leg standing phase.

The aim of the criterion 'stand up straight within three seconds after landing' is to assess the ability to maintain balance in the transition from dynamic movement to static state, which is usually quantified by measuring time to stabilization. We considered it as an essential criterion to assess dynamic stability and expected that the experts would agree on including it for all three skills. Yet, the 'three second' criterion was accepted only for SSHH. This criterion also achieved consensus for 90JH, yet it was ultimately not accepted as it was ranked last among the six criteria for 90JH. While the assessment of dynamic stability using the criterion seems important for all three skills, it may be more important for SSHH. As indicated above, the lateral jump-landing showed higher time to stabilization score than the forward jump-landing, in other words, individuals were less successful to maintain balance in the lateral jump-landing.[45,46] For 90JH and OTHH in which this criterion is not used, there are alternative proposed methods of assessing balance ability. Checking errors during the stabilization phase after landing (e.g. touching the floor with the free-leg) might be included to verify the number of successful landing to stabilization.[156] However, more than three trials may be needed to increase the sensitivity of measurement. In addition, substitutional information about one's balance ability can be provided using the criterion 'knee and hip bend slightly to land softly in a controlled fashion'. The achievement of this criterion may determine a well-balanced landing. A soft landing in a 'controlled fashion' connotes that the subject lands with a controlled posture in a minimal body sway. A child who lands with an excessive sway is considered to have reduced postural control and will fail to achieve the criterion.

The criterion 'Whole body turns together' was suggested by an expert in the first round for 90JH and was accepted. Trunk motion while airborne is related with biomechanics during landing. Trunk rotation towards the landing leg is related with increased peak valgus moments, knee abduction angle, and knee internal rotation angle and decreased knee flexion during landing.[164,167,168] If a child engages the rotation by turning torso followed by turning the lower body in 90JH, the child might be at risk of ACL injury. Alternatively the child might rotate their foot first and land even before the torso is completely rotated, which would likely influence lower extremity biomechanics. The ability to maintain whole body aligned may depend on core muscles because core is considered a kinetic link that facilitates the transfer and control of force between the upper body and lower body due to its location as the centre of the kinetic chain.[97] The angular momentum produced by ground reaction force during the rotational jump is applied on the lower body then the core as the link transfers the force through the upper body to rotate together. On the landing, the rotation of the lower body is stopped by contacting the ground then the core muscles need to activate to decelerate the upper body rotation.[161] If the core muscles are weak, resulting in an unsteady link, the lower body and upper body will work as two disconnected units. Injury risk will be increased as an upper body motion disassociated from lower body while landing is considered as lower extremity injury risk factor. [164,167,168]

The criterion 'Hands on hips' was associated to the three accepted BSs as well as six other BSs. Inclusion was to prevent the influence of arm movement on the results of the test, thereby providing a better reflection of balance ability.[180] Literature indicates that arm movement influences the score of Y-balance tests and tandem gait in children, suggesting that standardized hands position should be incorporated into the tests for balance ability in children.[181] Unexpectedly, no consensus was achieved on 'hands on hips' in all nine BSs (**Table 5**). The experts commented that good movers might use their arms effectively to control the posture thus the arm movement should be considered as a 'strategy' to maintain balance and hands kept on hips may prohibit children to solve the movement problem. If the arm movement helps to maintain balance, it may be disadvantageous to restrict it and should not be considered as inappropriate movement. The experts also argued that the focus needs to be on 'what a child does' rather than 'what a child can do'. In other words, we should appraise the behavioral tendencies that might also be seen in a normal physical activity environment. For instance, it may be less important if a child can keep their hands on hips while performing, it is likely more important to screen how a child moves their arms, to identify any movement pattern that can increase injury risk or delay motor development. A child, who can score higher than the other children in the single-leg stance with hands on the hips, may have higher fall risk in actually physical activity if the child does not use his arms effectively. In other words, arm movement, as a strategy, should be considered as part of postural control ability in terms of fall prevention/injury prevention. The meaning of arm movement during balance test can depend on the aim of the test. If the goal of the test is to assess balance ability relating to sensory systems (e.g. balance test for people with concussion), any arm movement to compensate body sway will be considered as an error or a confounder (e.g. Balance Error Scoring System[87]). Thus, considering the comments and the aim of study, it was suggested to screen the movement pattern and body position without using arm restriction. However, arm movement can be often limited in various physical activities in which children control an object with their hands such as basketball, field hockey, and lacrosse[182], indicating that maintaining balance with the arms restricted can be also required to participate in physical activity. In addition, in the study by Chaudhari *et al.*,[182] individuals with restricted arm movement showed increased valgus moments in single-limb landing, thus children might expose more distinct signs of lower body in jump-landing tests. Both aspects (arms-free ad arms-restricted) are important while 'hands kept on hips' increases the difficulty of balance tests. Therefore, the key criterion for selection of hands position (free or restricted) may depend on which method has the 'appropriate difficulty' for children 8-12 years of age. In the study by Hill *et al.,*[181] there was no significant difference on dynamic postural stability index which was assessed using forward jump-landing task, between 'arms movement without restriction' and 'arms placed on chest', suggesting a possible ceiling effect on this task in children 10-11 years of age. If that is the case, children may better perform with their arms restricted and any arm movement would result in a failed trial. It is still not clear because our study also involves children 8-9 years of age and forward jump-landing is considered to be easier than the lateral jump-landing.[44,45,46] A similar argument can be made on the criterion 'upper body straight'. 'Upper body straight' was associated to seven BSs (**Table.5**) but the criterion did not achieve consensus in all. While swaying upper-body can reflect the lack of postural control, children may use upper-body motion as part of hip strategy to bring the center of mass back over the base of support. Hip strategy may occur when balancing on narrow base of supports and on unstable surfaces.[131] The seven BSs that possess the criterion 'upper body straight' are performed on narrow base of supports (single-leg stance and tandem stance) and/or on unstable surface, implicating that the hip strategy can be an important component in those tests.

Lower extremity biomechanical variables (e.g. body positions, joint angles, joint moments, and ground reaction force) and the dynamic stability (e.g. center of pressure, time to stabilization) can be measured accurately in laboratory setting but it is time-consuming and expensive. According to Hewett *et al.,* [175] there is a need for simple 2D measurements to be used in field setting for a larger scale. Screening landing from a jump task using the evaluation criteria is time-saving and cost effective. Assessing balance and lower body posture at the same time by screening landing may be beneficial due to the relationship between balance ability and lower extremity biomechanics. Poor balance is associated with higher knee valgus moments and less hip flexion upon a single-leg landing[172] and balance training can increase knee flexion and reduce knee valgus during a drop-landing task.[173,174] This relationship may give supplement information or allow the rater to have different interpretation depending on the combination of achieved criteria. For instance, a child who failed to achieve 'knees and toes aligned' and/or 'knee and hip bend slightly to land softly in a controlled fashion' followed by failure of stabilization after landing may be due to poor balance ability. If it is true, the implementation of balance training would improve on lower extremity alignment. A child who failed to achieve only 'knee and hip bend slightly to land softly in a controlled fashion' may lack of experience on landing task or lack of muscle strength responsible for eccentric contraction during landing.

Static balance

Three BSs 'Single-leg Balance Eyes-closed', 'Single-leg Balance on Unstable surface', 'Single-leg Balance on Unstable surface + Catch a ball' were included as static balance tests. Single-leg balance is frequently used to assess static balance and is simple, cost-effective, and applicable in most of settings for a large scale.[183] The experts reached consensus on 'Single-leg Balance Eyes-closed' but not on 'Single-leg Balance on Unstable surface + Catch a ball' and 'Single-leg Balance on Unstable surface'. Since we aimed to select one static BS that is more appropriate than the others, the results accorded with our intention. However, it was not expected that all three static BSs had less than four criteria that achieved consensus while the other BSs had four or more criteria (except one BS) (Table.5). Consequently, 'Single-leg Balance Eyes-closed' was not accepted despite consensus achieved. It could be simply because the criteria for the static BSs were not important or these results may implicate that static BSs are not suitable for a process-oriented measurement. The criteria associated to the static BSs are related to the additional constraints or errors (e.g. hands on hips, eye closed, and legs do not touch). The test construct is similar with that of Balance Error Scoring System (BESS). BESS is more commonly used to identify balance deficit of individuals with history of concussion or ankle instability than assessment of balance ability in healthy population.[87] In literature, use of the maximum time in static balance as determinant of injury risk and balance deficit prevails[183,184] however, this component was not involved since it is a product-oriented measurement and time-consuming.

Static balance is considered to be related to injury risk and is often used to assess children's balance.[183,184] However, it has been suggested that assessment of static balance using single-leg stance might not be enough to evaluate balance performance since dynamic conditions are more related to the movement deficits associated with balance performance in the participation of many physical activities.[185] De Kegel et al.[179] found correlations between static balance (one-leg stance balance) and dynamic balance (balance beam walk, one-leg hop) and concluded that the functional dichotomization into static and dynamic balance is artificial. Considering the suggestions from literature, the absence of static balance may not threaten the validity of the assessment tool, moreover, it may not be necessary to include this aspect of balance assessment.

Reactive Postural Control

Another component that needs to be discussed is 'reactive postural control (RPC)'. RPC were not directly linked to evaluation criteria in our study, but RPC is considered to be the primary component for fall prevention.[118] RPC is commonly assessed in laboratory setting using surface perturbations on force platform (e.g. force platform translates forward in single-leg stance). In such way, the subject tries to stabilize their posture, bring the center of mass over the base of support after loss of balance.[186] However, according to Sibley et al.,[162] only one of 239 physiotherapists who reported their methods to assess RPC answered using a computerized balance assessment system (e.g. force platform, balance master) and use of non-standardized perturbations was the method used the most by 104 physiotherapists (43.5%). It is understandable that the use of non-standardized perturbation is preferred over the computerized system in clinical setting, despite the outcome from the computerized system being more accurate and sensitive, considering the cost, equipment, and time required and it is probably the same in many other settings (e.g. school, field). Non-standardized perturbations such as rater-induced perturbation may be usable to identify impaired balance ability or serious balance deficit of a patient in clinical setting where the goal is often to have supplemental information or to distinguish normal and abnormal level of balance ability. Nonetheless, the inconsistent amount of force that is applied to the subject can be a factor that seriously threatens the reliability of the result in the assessment of balance ability. One alternative way to assess RPC is to assess dynamic balance on unstable surface (e.g. BOSU ball, balance foam). For example, when performing jump and land on a balance foam, the subject will use anticipatory postural control to prepare the landing as the first action, then use RPC to adapt to rapid changes of surface after landing.[162] 'Alternate knee-up and Hold on Unstable Surface' and 'Step-up and Hold on Unstable Surface' were proposed as dynamic BSs aiming to assess RPC but were not accepted with lower percentage of agreement (Table. 5). An expert mentioned that these skills are different but have similar constructs with 'hop-land and hold' skills (TOHH, SSHH, 90JH) apart from the surface differences. Both types of BS (land and hold on unstable surface and stable surface) require the anticipatory adjustment for the controlled landing and RPC to stabilize posture after landing. While the use of unstable surface would require more RPC to react to the unpredicted changes of surface, the postural stability would still be interrupted by ground reaction force and the inertia in the 'hop-land and hold' skills performed on stable surface therefore use of RPC is required.[163] Thus, observing the movements after landing (e.g. the criterion 'Stand up straight within three seconds after landing' in TOHH; knee, ankle, and hip strategies) in the 'hop-land and hold' skills may be used to identify RPC deficit.

Final ranking

In the third round, the expert panel ranked the items that achieved consensus. Total of ten skills including seven locomotion skills (bodyweight squat, single-leg hop, running, vertical jump, horizontal jump, walking lunge, leaping) were in the final list. Locomotor skills were not included in this study but they are part of the FMS assessment tool and were involved in another study. Regardless the ranking, all three BSs were accepted since the aim of study was to include top four skills in the ranking. The BSs were placed low in the ranking (TOHH: 7th; SSHH: 8th; 90JH: 10th). The ranking, in general, corresponds with the percentage of agreement. The top six skills had higher than 80% of agreement and the four skills from seventh place to last place had lower than 80% of agreement except SSHH (100% of agreement). The locomotion skills ranked higher are included in many motor assessment tools for children and considered valid and reliable[15,70,82,155,156] while the BSs are not seen often in the existing motor assessment tools for children (only included in Passport for life[156]). Moreover, several comments were made to point that the BSs accepted are not considered as FMS, are rather functional movements. These comments are supported by Tompsett & McKean.[34] In their research, squat, jumping, hopping, lunge, and running are classified as foundation skill or fundamental skill while land from a jump is classified as sports and play skill that is considered to be more advanced. Given the information, the experts may have found the BSs less important in terms of FMS assessment than the locomotion skills ranked higher. Still, the expert panel reached consensus on the three BSs and it may be because they valued the importance of the skills on injury prevention since landing to stabilization skills are commonly used in IPPs.[69,70,72,74,75,129,130,153,156]

Limitations

The primary limitation of this study is that some of the experts opted out during the process. The participants were considered to have the expertise that values greatly in the study thus loss of each expert may decrease the quality of the results. A couple of factors may have contributed to this situation. The survey was time-consuming. An expert in the second round expressed that the expert had to opt out because it took too long to complete the survey. We originally expected that the survey would take about 30 to 45 minutes however, many of experts spent more than one hour to complete the survey. Another factor is that there was no individual feedback on the questions or suggestions made within the survey. The individual feedback was not used to minimize the time-gap between the rounds. However, it can be assumed that this contributed to the drop-out rate since all of four experts who had questions in the first round did not participate in the second round.

We can also assume that some elements in the survey were not clearly understood by the experts based on their comments. As a result, some modifications were made between the first round and the second round, which may have caused potential confusion. First, use of 'internal focus cues' as the evaluation criteria in the first round made some experts unsure about the purpose of the cues whether they are to evaluate the movements or to instruct the children since 'internal focus cues' are, in general, used to give an instructions. Second, some of BSs were similar to each other (the three BSs on single-leg stance, the three hop-land and hold BSs) and some experts doubted the necessity of including all of them because they thought that our goal is to include all of the BSs proposed. We aimed to select four BSs to be included in the screening tool. In addition, some of descriptions of BSs were not clear on their purpose. For example, an expert suggested that it would be challenging to measure the degree of the jump in 90-degree Jump and Hold but the focus in the skill was on the landing and stabilization of posture not on the jump itself.

According to Avella[136], the modified Delphi method has several limitations and they may have affected the results of this study. Researcher bias can be generated by who is invited as the panel member and how the researcher formulates the survey. Researchers may appoint themselves as arbiters of selection of experts. It should be the discipline and experience that determine the expertise, not the researcher. To avoid this bias, we used Knowledge Resource Nomination

Worksheet (KRNW)[144] to evaluate participants' qualifications. Nevertheless, personal judgement may not have been excluded completely because it was not always clear whose expertise would value more based on the information provided. Another disadvantage of the Delphi method is that the researcher has an extraordinary authority and influence in the process. The researcher has control over the characteristics of survey such as the order of question, the information included, and the survey design in general. This shortcoming is accentuated especially in the modified version because the initial items in the first round were selected by the researcher. Even though the experts can still suggest new items, the researcher has the authority to choose whether or not to include the suggested item in the next survey.

Conclusion

In conclusion, this study provided initial validation for the FMS assessment tool for children 8-12 years of age through the Delphi process. The modified Delphi method was used because it is applicable when there is no clear evidence for a specific topic. Consensus was achieved on including three BSs (90JH, SSHH, OTHH) and four associated evaluation criteria associated to each skill among the international experts in the domain of movement competence and injury prevention. Remarkably, only BSs that are aimed to assess dynamic balance during landing to stabilization were accepted. Such being the case, according to Sibley *et al.,*[117] there are some balance assessment components (static balance, reactive postural control) missing in the assessment tool. It is open to debate if all the missing balance components should be included to have a valid balance assessment and to determine one's injury risk.

This is the first study that incorporated injury prevention into FMS assessment for children. The FMS assessment tool is cost-effective and time-efficient and can be used in various settings. The tool uses a process-oriented assessment in which problematic movement patterns that can increase potential injury risk factors and delay the motor development could be identified. Injury prevention techniques derived from current IPPs and applied to a FMS assessment will provide the practitioners with a better understanding to identify potential injury risk factors whiling assessing children's movement skills. The inclusion of balance component into the assessment greatly improves the quality of the assessment due to its contribution to motor development and injury prevention.

There should be an endeavor to reduce injury risk because potential injuries exist in every physical activity. Correction of movement deficits through use of the assessment with the tool could result in reduced injury and enhanced motor development and, ultimately, promote children's healthy life style. This work can guide planning physical activity programs or training programs. A possible area for future research would be to evaluate the feasibility and reliability of the tool, to see if the tool can be used for the target population in various settings.

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Figures and Tables

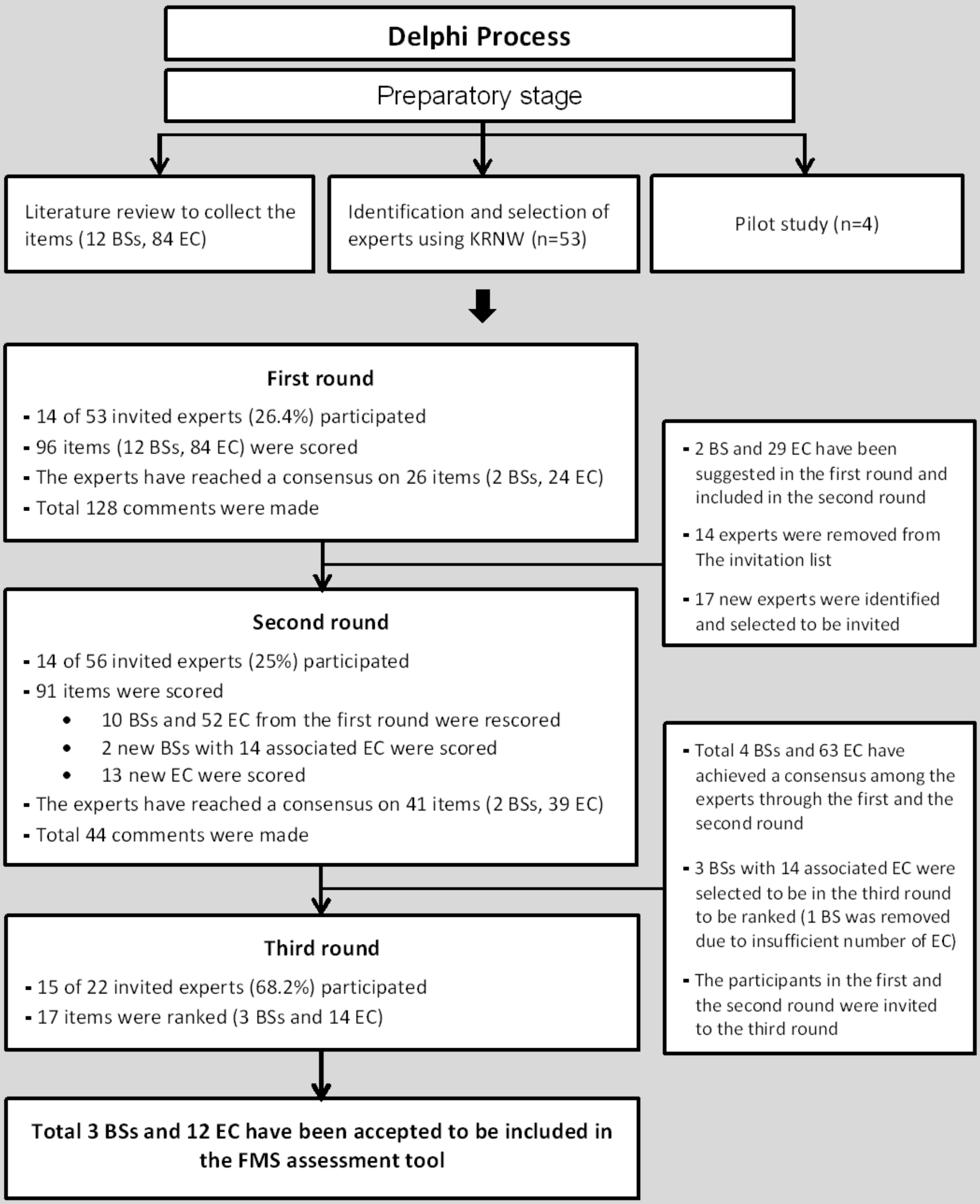

FIGURE 1. The study flow chart for all three rounds
*Abbreviations: **BS**, balance skill; **EC**, evaluation criteria; **KRNW**, knowledge resource nomination worksheet*

Table 1. Balance skills in injury prevention programs

Injury prevention programs	Balance skills
FIFA 11+ [69]	-Single-leg stance 1) Holding the ball 2) Throwing the ball 3) Perturbation -Lateral jumps -Single-leg squat
FIFA 11+ Kids[70]	-Single-leg stance 1) On the stop comment while running 2) Holding the ball 3) Moving the ball around with the free-leg 4) Perturbation -Single-leg dynamic balance 1) Holding the ball and touching the ground with the ball 2) Holding the ball and stretching the free-leg backwards with both arms forward -Lateral jumps -Backward and forward jumps
Harmoknee[71]	-Forward and backward double leg hops -Lateral single-leg hops -Forward and backward single-leg hops -Double leg hop with or without ball
Prevent Injury and Enhance Performance(PEP)program[72]	-Lateral hops -Forward hops -Single-legged hops
The Gaelic Athletic Association 15 training program(GAA 15)[73]	-Single-leg Romanian Dead-lift
FootyFirst[75]	-Single-leg standing -Single-leg squat -Jump forward and land on one leg -Jump backward and land on one leg -Run forward, jump and land -Run, jump to the side and land -Run, jump, land and recover to run
Injury prevention warm-up program (Sports Injury Prevention Centre of University of Calgary)[77]	-Wobble board 1) Two-foot balance 2) Two-foot balance with ball 3) Activities 4) Two-foot balance with partner 5) Perturbations -Balance pad 1) Single-leg balance Single-leg balance with activities (Tossing, Dribbling or Partner perturbations) 2) Single-leg balance with eyes closed

Table 2. Delphi expert panel characteristics

Experts (n=22)		n (%)
Gender		
	Female	8 (36.4)
	Male	14 (63.6)
Age		
	22-29	5 (22.7)
	30-39	6 (27.3)
	40-49	5 (22.7)
	50-59	5 (22.7)
	60-69	1 (4.5)
Degree		
	Bachelor	6 (27.3)
	Masters	4 (18.2)
	Doctorate	12 (54.5)
Years of experience		
	Under 5	2 (9.1)
	5-9	5 (22.7)
	10-14	3 (13.6)
	15-19	7 (31.8)
	20-24	1 (4.5)
	25-29	2 (9.1)
	30 and over	2 (9.1)
Primary Affiliation		
	Professor	6 (27.3)
	Lecturer or instructor	2 (9.1)
	Research associate or postdoctoral associate	5 (22.7)
	Athletic Therapist	3 (13.6)
	Other*	6 (27.3)
Location		
	Canada	13 (59.1)
	U.S.A	4 (18.2)
	U.K	3 (13.6)
	Australia	1 (4.5)
	Switzerland	1 (4.5)

**Includes : Physical literacy specialist, Executive director of non-profit organisation, PhD candidate, Head of high performance, Private business owner (performance center)*

Table 3. Expertise distribution in each round

Primary field of expertise	All rounds	Round 1	Round 2	Round 3
Injury prevention area	13 (59.1)	8 (57.1)	10 (71.4)	11 (73.3)
Athletic therapy/training	7 (31.8)	5 (35.7)	5 (35.7)	6 (40)
Biomechanics	1 (4.5)	1 (7.1)	1 (7.1)	1 (6.7)
Injury prevention	2 (9.1)	1 (7.1)	2 (14.3)	2 (13.3)
Physical therapy	2 (9.1)	0 (0)	2 (14.3)	2 (13.3)
Strength and Conditioning	1 (4.5)	1 (7.1)	0 (0)	0 (0)
Motor competence area	9 (40.9)	6 (42.9)	4 (28.6)	4 (26.7)
Children and Adolescent	2 (4.5)	1 (7.1)	2 (14.3)	1 (6.7)
Motor development	4 (18.2)	2 (14.3)	2 (14.3)	2 (13.3)
Physical literacy	3 (13.6)	3 (21.4)	0 (0)	1 (6.7)
Total participants	22 (100)	14 (100)	14 (100)	15 (100)

** Values are n (%) unless otherwise indicated.*

Table 4. Balance Skills derived from the literature

Balance Skills	Descriptions	Balance Assessment Component
Single-leg Balance Eyes Closed [77,83,87,88]	Stand on one leg with the free-knee bent to 45 degrees and the eyes are closed. Hold the position for ten seconds	-Static balance -Sensory Integration
Single-leg Balance on Unstable Surface [75,77,84,87,88]	Stand on a foam pad on one leg. The free-knee is bent to 45 degrees. Hold the position for ten seconds	-Static balance
Single-leg Balance on Unstable Surface + Catch a Ball [69,70,76,77]	Stand on a foam pad on one leg. The free-knee is bent to 45 degrees. A ball is thrown underhand by another person, and balance is assessed while catching the ball	-Static balance -Cognitive influences
Single-leg Romanian Deadlift[70,73,129,148]	Stand on one leg. Stretch the arms forward and then raise one leg backward while bending forward slowly until the arms, leg, and torso are aligned parallel to the ground	-Anticipatory postural control -Core stability
Single-leg Squat [129,132,154]	Stand up straight on one leg, descend half way (approximately 50 degrees of the knee flexion), and ascend without losing balance	-Anticipatory postural control
Heel to toe Walking [83,84,85]	Walk in a straight line by putting the heel of the front-foot in front of the toes of the back-foot and then walk backward in the same fashion by placing the back-foot directly behind the other foot in a straight line on the floor	-Anticipatory postural control -Dynamic balance
Two to One-foot Hop and Hold [70,71,72,74,75,129,130]	Start with their feet together, hop forward, land on one foot, and hold the position for five seconds	-Anticipatory postural control -Dynamic balance
Single-leg Sideways Hop and Hold [69,70,71,72,74,82,83,130]	Start by standing on one leg, jump to the side of the free-leg, land with the free-leg, and hold the position for five seconds	-Anticipatory postural control -Dynamic balance
90-degree Jump and Hold[74,76,130,153]	Stand on the right leg, jump and turn their body 90 degrees to the right, land on the right foot, and hold the position for five seconds. Repeat the same movement on the other side.	-Anticipatory postural control -Dynamic balance
Step-up and Hold on Unstable Surface [67,68,150]	Step up on a foam balance pad placed on a board (around mid-tibia level or lower) and hold a single-leg position for five seconds.	-Anticipatory postural control -Reactive postural control -Dynamic balance
Alternate Knee-up and Hold on Unstable Surface[67,68,149,150]	Start in a single-leg stance position with the foot on a foam balance pad. Shift the weight from one leg to the other without jumping. Finish the movement in a single-leg stance position and hold the position for five seconds.	-Anticipatory postural control -Reactive postural control -Dynamic balance
Bird-dog Exercise [112,113,145]	Start with hands and knees on the floor and raises simultaneously one arm and the opposite leg until they are aligned and parallel to the floor. Hold the position for five seconds.	-Anticipatory postural control -Core stability

Table 5. Percentages of agreement on including the items into the FMS assessment tool

List of items		First round (%)	Second round (%)	Consensus
First round	Second round (reworded or renamed)			
Single-leg Balance Eyes Closed	**Single-leg Balance Eyes Closed**	92.9*	–	Y
Eyes closed	Eyes closed	76.9*	–	Y
Foot flat on the floor	Foot flat on the floor	92.9*	–	Y
Keep your hands on your hips	Hands on hips	64.3	71.4	N
Keep your chest up	Upper-body straight	64.3	64.3	N
Legs do not touch	Legs do not touch	50	57.1	N
Keep your toes pointing forward	Toes pointing forward	50	57.1	N
Hold the position for ten seconds	Holds the position for ten seconds	71.4	78.6*	Y
Single-leg Balance on Unstable Surface	**Single-leg Balance on Unstable Surface**	71.4	71.4	N
Look at the cone Keep your chest up	Upper-body straight and eyes focused on the cone (placed two meters ahead) [a]	57.1 64.3	57.1	N
Keep your hands on your hips	Hands on hips	57.1	50	N
Legs do not touch.	Legs do not touch	35.7	57.1	N
Keep your toes pointing forward	Toes pointing forward	50	64.3	N
Foot flat on the balance pad	Foot flat on the balance pad	78.6*	–	Y
Hold the position for ten seconds	Holds the position for ten seconds	71.4	92.9*	Y
	Support-knee slightly bent [b]	–	57.1	N

** Item with a consensus achieved (agreement among the experts ≥ 75%)*

[a] Criterion combined with two criteria in the first round [b] New item added in the second round based on suggestions from the experts

Note : The evaluation criteria were reworded in the second round

Table 5. Percentages of agreement on including the items into the FMS assessment tool (continued)

List of items		**First round (%)**	**Second round (%)**	**Consensus**
First round	Second round (reworded or renamed)			
Single-leg Balance on Unstable Surface + Catch a Ball	**Single-leg Balance on Unstable Surface + Catch a Ball**	50	50	N
Keep your head up	Upper-body straight [a]	75*	50	N
Keep your chest up		66.7		
Bend your knee slightly	Support-knee slightly bent	66.7	85.7*	Y
Legs do not touch	Legs do not touch	41.7	35.7	N
Keep your toes pointing forward	Toes pointing forward	58.3	57.1	N
Foot flat on the balance pad	Foot flat on the balance pad	75*	–	Y
Stay still while catching the ball	Stay still throughout	50	35.7	N
Single-leg Romanian Deadlift	**Single-leg Hip Hinge** [c]	42.9	35.7	N
Keep your arms extended forward	Arms extended forward	57.1	71.4	N
Foot flat on the floor	Foot flat on the floor	85.7*	–	Y
No rotations of the upper body and the pelvis	No excessive rotations of the Upper-body and the pelvis	57.1	78.6*	Y
Keep your toes pointing forward	Toes pointing forward	64.3	64.3	N
Descend until the body is parallel to the ground	Descend until the body is parallel to the ground	64.3	85.7*	Y
No excessive body movement throughout	No excessive body movement throughout	64.3	78.6*	Y
Hold the position for five seconds	Holds the position for five seconds	64.3	78.6*	Y
	Support-knee slightly bent [b]	–	78.6*	Y
	Back straight (neutral spine) [b]	–	85.7*	Y

** Item with a consensus achieved (agreement among the experts ≥ 75%)*

[a] Criterion combined with two criteria in the first round

[b] New item added in the second round based on suggestions from the experts *[c] Renamed in the second round*

Table 5. Percentages of agreement on including the items into the FMS assessment tool (continued)

List of items		First round (%)	Second round (%)	Consensus
First round	Second round (reworded or renamed)			
Single-leg Squat	**Single-leg Squat**	64.3	64.3	N
Keep your head up	Upper-body straight and eyes focused forward	57.1	57.1	N
Keep your hands on your hips	Hands on hips	50	28.6	N
Do not let your knee go too far in front of your toes	Knee does not go too far in front of toes	50	78.6*	Y
Keep your toes pointing forward	Toes pointing forward	64.3	78.6*	Y
Foot flat on the floor	Foot flat on the floor	85.7*	–	Y
Do not let your knee come in	Knee and toes aligned	64.3	92.9*	Y
No excessive body movement throughout	No excessive body movement throughout	71.3	92.9*	Y
	Hip does not drop [b]		50	N
Heel to Toe Walking	**Heel to Toe Walking**	61.5	64.3	N
Keep your head up	Upper-body straight [a]	71.4	64.3	N
Keep your chest up		57.1		
Keep your hands on your hips	Hands on hips	64.3	50	N
Two feet (or one foot) remain contact on the line	Maintains contact with the line throughout the movement	71.4	92.9*	Y
Heel and toes touch on each step	Heel and toes touch on each step	78.6*	–	Y
No pause between steps	No pause between steps	57.1	78.6*	Y
No excessive body movement throughout	No excessive body movement throughout	64.3	85.7*	Y

** Item with a consensus achieved (agreement among the experts ≥ 75%)*

[a] *Criterion combined with two criteria in the first round* [b] *New item added in the second round based on suggestions from the experts*

Table 5. Percentages of agreement on including the items into the FMS assessment tool (continued)

List of items: First round	List of items: Second round (reworded or renamed)	First round (%)	Second round (%)	Consensus
Two to One-foot Hop and Hold	**Two to One-foot Hop and Hold**	78.6*	–	Y
Keep your hands on your hips	Hands on hips	57.1	35.7	N
Bend your knee slightly when landing	Knee and hip bend slightly to land softly in a controlled fashion	85.7*	–	Y
Stand up straight within three seconds after landing	Stand up straight within three seconds after landing	64.3	71.4	N
Keep your toes pointing forward	Toes pointing forward	78.6*	–	Y
Legs do not touch	Legs do not touch	53.8	50	N
Do not let your knee come in	Knee and toes aligned	71.4	100*	Y
Foot flat on the floor	Foot flat on the floor	78.6*	–	Y
	Knee does not go too far in front of toes [b]	–	71.4	N
Single-leg Sideways Hop and Hold	**Single-leg Sideways Hop and Hold**	71.4	100*	Y
Keep your hands on your hips	Hands on hips	46.2	71.4	N
Bend your knee slightly when landing	Knee and hip bend slightly to land softly in a controlled fashion	84.6*	–	Y
Stand up straight within three seconds after landing	Stand up straight within three seconds after landing	61.5	78.6*	Y
Keep your toes pointing forward	Toes pointing forward	61.5	71.4	N
Legs do not touch	Legs do not touch	61.5	71.4	N
Do not let your knee come in	Knee and toes aligned	76.9*	–	Y
Foot flat on the floor	Foot flat on the floor	92.3*	–	Y

** Item with a consensus achieved (agreement among the experts ≥ 75%)* [b] *New item added in the second round based on suggestions from the experts*

Table 5. Percentages of agreement on including the items into the FMS assessment tool (continued)

List of items		First round (%)	Second round (%)	Consensus
First round	Second round (reworded or renamed)			
90-degree Jump and Hold	**90-degree Jump and Hold**	71.4	78.6*	Y
Keep your hands on your hips	Hands on hips	46.2	14.3	N
Bend your knee slightly when landing	Knee and hip bend slightly to land softly in a controlled fashion	92.3*	–	Y
Stand up straight within three seconds after landing	Stand up straight within three seconds after landing	61.5	78.6*	Y
Keep your toes pointing forward	Toes pointing forward	61.5	78.6*	Y
Legs do not touch	Legs do not touch	53.8	71.4	N
Do not let your knee come in	Knee and toes aligned	76.9*	–	Y
Foot flat on the floor	Foot flat on the floor	92.3*	–	Y
	Whole body turns together [b]	–	85.7*	Y
Step-up and Hold on Unstable Surface	**Step-up and Hold on Unstable Surface**	41.7	21.4	N
Keep your head up	Upper-body straight and eyes focused forward [a]	76.9*	57.1	N
Keep your chest up		38.5		
Keep your hands on your hips	Hands on hips	61.5	14.3	N
Stand up straight within three seconds after "step-up	Stand up straight within three seconds after "step-up"	61.5	78.6*	N
Do not let your knee come in	Knee and toes aligned	76.9*	–	Y
Keep your toes pointing forward	Toes pointing forward	76.9*	–	Y
No pause during the step-up movement	No pause during the step-up movement.	83.3*	–	Y
	Hip does not drop [b]	–	42.9	N

** Item with a consensus achieved (agreement among the experts ≥ 75%)*

[a] Criterion combined with two criteria in the first round [b] New item added in the second round based on suggestions from the experts

Table 5. Percentages of agreement on including the items into the FMS assessment tool (continued)

List of items		First round (%)	Second round (%)	Consensus
First round	Second round (reworded or renamed)			
Alternate Knee-up and Hold on Unstable Surface	**Alternate Knee-up and Hold on Unstable Surface**	23.1	64.3	N
Keep your head up	Upper-body straight [a]	69.2	71.4	N
Keep your chest up		53.8		
Keep your hands on your hips	Hands on hips	46.2	28.6	N
Stand up straight within three seconds after landing	Stand up straight within three seconds after landing	46.2	50	N
Keep your toes pointing forward	Toes pointing forward	69.2	78.6*	Y
Do not let your knee come in	Knee and toes aligned	69.2	92.9*	Y
No pause when shifting your knees	No pause between shifting the knees	53.8	42.9	N
	Foot flat on the foam pad [b]	–	64.3	N
Bird-dog Exercise	**Bird-dog Exercise**	61.5	57.1	N
Look at the cone (placed one meter ahead)	Eyes focused on the cone (placed one meter ahead)	61.5	42.9	N
Keep your free-arm, body, and free-leg parallel to the ground	Free-arm, body, and free-leg are parallel to the ground	75*	–	Y
No rotations of the upper body and the pelvis	No rotations of the Upper-body and the pelvis	58.3	85.7*	Y
Keep the free-arm straight forward and the free-leg straight backward	Free-arm straight forward and free-leg straight backward	83.3*	–	Y
Keep your back straight (neutral spine)	Back straight (neutral spine)	76.9*	–	Y
No excessive body movement throughout	No excessive body movement throughout	69.2	71.4	N
Hold the position for five seconds	Holds the position for five seconds	69.2	85.7*	Y

** Item with a consensus achieved (agreement among the experts ≥ 75%)*

[a] Criterion combined with two criteria in the first round [b] New item added in the second round based on suggestions from the experts

Table 5. Percentages of agreement on including the items into the FMS assessment tool (continued)

List of items		First round (%)	Second round (%)	Consensus
First round	Second round (reworded or renamed)			
	Sing-leg Front Plank [b]	–	64.3	N
	Elbows under shoulders [b]	–	100*	Y
	Toes on the floor [b]	–	92.9*	Y
	Leg parallel to the ground or higher [b]	–	92.9*	Y
	No excessive rotation of the upper body and the pelvis [b]	–	92.9*	Y
	Back straight throughout [b]	–	85.7*	Y
	Straight line from head to ankles [b]	–	100*	Y
	Holds the position for five seconds [b]	–	85.7*	Y
	Side Plank [b]	–	50	N
	Elbow under shoulder	–	92.9*	Y
	Free-arm extended towards the ceiling [b]	–	42.9	N
	Straight line from head to ankles [b]	–	92.9*	Y
	Whole body rolls over together (linear rotation) [b]	–	57.1	N
	No pause during rotation [b]	–	50	N
	Stay balanced throughout the movement [b]	–	85.7*	Y
	Holds the position for five seconds [b]	–	85.7*	Y

** Item with a consensus achieved (agreement among the experts ≥ 75%)*

[b] New item added in the second round based on suggestion from the experts

Table 6. Description of balance skills in the first round and the second round

Balance Skills	First round description	Second round description (modified)
Single-leg Balance Eyes Closed	This skill is a single-leg standing posture on the dominant leg with eyes closed	The child will stand on one leg with the free-knee bent to 45 degrees and free-hip bent to 30 degrees. The child closes their eyes and holds this position for ten seconds
Single-leg Balance on Unstable Surface	Stand up straight on the dominant leg on a foam balance pad	The child will stand on a foam pad on one leg. The free-knee will be bent to 45 degrees and the free-hip will be bent to 30 degrees. The child will hold this position for ten seconds
Single-leg Balance on Unstable Surface + Catch a Ball	The child will stand up straight on the dominant leg on a foam balance pad while catching a ball thrown underhand by another person	The child will stand on a foam pad on one leg. The free-knee will be bent to 45 degrees and free-hip bent to 30 degrees. A ball will be thrown underhand by another person, and balance will be assessed as the child catches the ball
Single-leg Romanian deadlift (Single-leg Hip Hinge)	This is a hip hinge movement while standing on one leg. The children will extend their arms forward and raise a leg backward while bending at the waist. The child will continue bending forward slowly, until the arms, leg, and torso are aligned parallel to the ground	Single-Leg hip hinge is performed while standing in one leg. The child will stretch their arms forward and then raise one leg backward while bending forward slowly until the arms, leg, and torso are aligned parallel to the ground
Single-leg Squat	Stand up straight on one leg. Descend and ascend without losing the balance	Single-Leg Squat involves descending the child's center of gravity by bending the knee and hip. The child will stand up straight on one leg, descend half way (approximately 50 degrees of the knee flexion), and ascend without losing balance
Heel to Toe Walking	The child will walk forward by putting the heel of the front foot in front of the toe of their other foot. The child will then walk backward in the same fashion by placing their back foot directly behind the other foot in a straight line on the floor	Heel to Toe Walking is a dynamic balance test in which a child is asked to walk in a straight line by putting the heel of the front-foot in front of the toes of the back-foot. The child will then walk backward in the same fashion by placing their back-foot directly behind the other foot in a straight line on the floor

Table 6. Description of balance skills in the first round and the second round (continued)

Balance Skills	First round description	Second round description (modified)
Two to One-foot Hold and Hold	Start with two feet together, jump forward, and land on one foot	Two to One-foot Hop and Hold is a balance test in which the child tries to recover and keep balance after landing. The child starts with their feet together, hops forward, lands on one foot, and holds the position for three seconds
Single-leg Sideways Hop and Hold	Start by standing on one leg. Jump to the side of the free-leg and land with the free-leg	Single-Leg Sideways Hop and Hold is a balance test in which the child tries to recover and keep balance after landing. The child starts by standing on one leg, jumps to the side of the free-leg, lands with the free-leg, and holds the position for three seconds
90-degree Jump and Hold	Start by standing on the right leg. Jump and turn the body 90 degrees to the right, and land on the right foot only. Repeat the same movement on their other leg	90-Degree Jump and Hold is a balance test in which the child tries to recover and keep their balance after landing. The child stands on the right leg, jumps and turns their body 90 degrees to the right. The child will land on the right foot, and hold the position for three seconds
Step-up and Hold on Unstable Surface	Step up on a foam balance pad placed on a bench and stand up on one leg	Step-up and Hold on Unstable Surface is a Step-up action in which the child reacts to the change of surface to recover their balance. The child steps up on a foam balance pad placed on a board (around mid-tibia level or lower) and holds a single-leg position for three seconds
Alternate Knee-up and Hold on Unstable Surface	Raise one knee in the air and shift quickly (without jumping) to raise the other knee in the air on a foam balance pad	Alternate Knee-up and Hold on Unstable Surface is a balance test that involves reacting to an unstable surface to recover balance after shifting weight from one leg to the other. The child starts in a single-leg stance position with their foot on a foam balance pad. The child will shift their weight from one leg to the other without jumping. The child will finish the movement in a single-leg stance position and hold this position for three seconds
Bird-dog Exercise	Start on the floor on their hands and knees. Simultaneously raise one arm and the opposite leg at the same time until they aligned parallel to the floor	Bird-Dog Exercise is a dynamic core stability exercise. The child starts with hands and knees on the floor and raises simultaneously one arm and the opposite leg until they are aligned and parallel to the floor. The child will hold the position for five seconds

Table 7. The final ranking of criteria for 90-Degree Jump and Hold

Evaluation Criteria	Score*	Rank
Knee and hip bend slightly to land softly in a controlled fashion	**12.5**	**1**
Knee and toes aligned	**11**	**2**
Whole body turns together	**10.5**	**3**
Toes pointing forward	**6.7**	**4**
Foot flat on the floor	5.7	5
Stand up straight within three seconds after landing	5.4	6

** Calculated by dividing the sum of inverted point value[136] by the number of the items ranked. The maximum score was 15, in which case all experts rank an item in the first place.*
Evaluation Criteria accepted were highlighted in bold

Table 8. Final list of items

Balance Skills	Evaluation Criteria
Two to One-foot Hop and Hold	Knee and hip bend slightly to land softly in a controlled fashion
	Toes pointing forward
	Knee and toes aligned
	Foot flat on the floor
Single-leg Sideways Hop and Hold	Knee and hip bend slightly to land softly in a controlled fashion
	Stand up straight within three seconds after landing
	Knee and toes aligned
	Foot flat on the floor
90-degree Jump and Hold	Knee and hip bend slightly to land softly in a controlled fashion
	Toes pointing forward
	Knee and toes aligned
	Whole body turns together

APPENDIX

The examples of the content of the surveys in all three rounds

First round survey

VALIDATION OF A FUNDAMENTAL MOVEMENT SKILLS SCREENING TOOL FOR 8-12-YEAR-OLD CHILDREN

Thank you for participating in this study. You have been selected to be part of this expert panel because of your expertise and knowledge.
In this round, you are asked to score 24 fundamental movement skills under two categories (12 locomotor skills and 12 balance skills) and seven internal focused cues for each movement using 5-point Likert scale (Strongly Disagree [1], Disagree [2], Neutral [3], Agree [4], Strongly Agree [5]).
Fundamental movement skills are considered part of the physical competence domain of physical literacy and have been evaluated using different tools as part of physical literacy assessments. However, we believe that there is no physical literacy assessment tool nor fundamental movement skills assessment tool associated with injury prevention techniques.
The proposed movement skills and internal focused cues are based on the literature and intend to be related to injury prevention. We decided to use internal focused cues, which place the focus on the process (quality) rather than the outcome (quantity) of the movement skills, in this screening tool. Moreover, the cues have been designed to be easily followed and understood by 8-12-year-old children.
Our aim is to reach consensus on at least four movement skills from each category and four internal focused cues associated to each skill. This screening tool is projected to be used to screen either a single child or a group of children using minimal people, equipment, and cost in most settings.
For this study, consensus on accepting a movement skill or cue is reached when 75% of the expert panel score an item equal to or higher than 4 (“Agree”). In contrast, consensus on discarding a movement skill or cue is reached when 75% of the expert panel score an item equal to or lower than 2 (“Disagree”). It would be unusual to reach consensus on eight movement skills and four cues associated to each skill in the first Delphi-round, so additional Delphi-rounds may be required. In the case that a movement skill is neither accepted nor discarded in a Delphi-round, the movement skill will be included in the next Delphi-round to be scored once again. The Delphi-rounds will stop when the minimum number of movement skills and cues is achieved. If more than four locomotor, four balance skills, and/or four cues associated to each movement skill have reached consensus on being accepted, a final round, where you will be asked to rank the movement skills and/or cues, will be performed. At least four movement skills

for each category and the top four internal focused cues for each movement skill will be included in the fundamental movement skills screening tool.

This first survey should take between 30 and 45 minutes to complete, but this survey will be the longest in this study because it contains all the movement skills and cues. Subsequent surveys will be shorter because the list of movement skills will be narrowed down through the process. In addition, new movement skills proposed in this survey by an expert could be included on the next Delphi-round, but we still expect the next survey to be shorter in length and time to completion.

We want to remind you to take the recommended health and safety precautions to work in a desk-based environment, including the desk and screen height, proper illumination, and taking regular breaks if needed. You can save your progress and leave the survey at any time by clicking on the link at the top right of the screen. You can resume the survey by following the instructions and clicking on a link that will be sent to you, or follow the original link that was sent to you in the invitation email.

Movement Skills and Internal Focused Cues

In this section, you will be asked to score the movement skills and the cues using a 5-point Likert scale. Even if you disagree on including a movement skill in the screening tool, please score the cues associated to the skill. If the other panel members believe that the skill is important we will include it on subsequent surveys attempting to reach consensus.

(Example. 1)
Single-Leg Balance Eyes Closed

This skill is a single-leg standing posture on the dominant leg with eyes closed.
The children will have one trial.
(Main balance assessment component: Static balance, Sensory integration)

Please indicate your level of agreement on including the above movement skill in a fundamental movement skills screening tool for 8-12-year-old children.
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree
Please choose only one of the following:
○ 1
○ 2
○ 3
○ 4
○ 5

Please indicate your level of agreement on whether the following internal focused cues are appropriate for the movement skill "Single-leg Balance Eyes Closed" to identify movement patterns that may represent low movement skills competence and/or a risk factor for injury?
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree
Please choose the appropriate response for each item:

	1	2	3	4	5
Eyes closed	○	○	○	○	○
Keep your hands on your hips	○	○	○	○	○
Keep your chest up	○	○	○	○	○
Legs do not touch	○	○	○	○	○
Keep your toes pointing forward	○	○	○	○	○
Foot flat on the floor	○	○	○	○	○
Hold position for ten seconds	○	○	○	○	○

Internal focused cues are related with the movement process or movement components and allow us to identify movement patterns that represent a risk for injury and are intended to be easy to understand and follow by an 8-12-year-old child.

Do you think that there are additional internal focused cues that could better identify the quality of movement and /or injury risk while performing "Single-leg Balance Eyes Closed"?
Please choose only one of the following:
○ Yes
○ No

Please list the internal focused cue(s).
Only answer this question if the following conditions are met:
Answer was 'Yes' (Do you think that there are additional internal focused cues that could better identify the quality of movement and /or injury risk while performing “Single-leg Balance Eyes Closed”?)

Please write your answer here:

(Example. 2)
Single-Leg Sideways Hop and Hold

Start by standing on one leg. Jump to the side of the free-leg and land with the free-leg.
The children will have one trial for each side (total two trials).
(Main balance assessment component: Dynamic balance, Anticipatory postural control)

Please indicate your level of agreement on including the above movement skill in a fundamental movement skills screening tool for 8-12-year-old children.
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree
Please choose only one of the following:
○ 1
○ 2
○ 3
○ 4
○ 5

Please indicate your level of agreement on whether the following internal focused cues are appropriate for the movement skill "Single-leg Sideways Hop and Hold" to identify movement patterns that may represent low movement skills competence and/or a risk factor for injury?
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree

Please choose the appropriate response for each item:

	1	2	3	4	5
Keep your hands on your hips.	○	○	○	○	○
Bend your knee slightly when landing.	○	○	○	○	○
Stand up straight within three seconds after landing.	○	○	○	○	○
Keep your toes pointing forward.	○	○	○	○	○
Legs do not touch.	○	○	○	○	○
Do not let your knee come in.	○	○	○	○	○
Foot flat on the floor.	○	○	○	○	○

Internal focused cues are related with the movement process or movement components and allow us to identify movement patterns that represent a risk for injury and are intended to be easy to understand and follow by an 8-12-year-old child.

Do you think that there are additional internal focused cues that could better identify the quality of movement and /or injury risk while performing "Single-leg Sideways Hop and Hold"?
Please choose only one of the following:
○ Yes

○ No

Please list the internal focused cue(s).
Only answer this question if the following conditions are met:
Answer was 'Yes' (Do you think that there are additional internal focused cues that could better identify the quality of movement and /or injury risk while performing “Single-leg Sideways Hop and Hold”?)

Please write your answer here:

NOTE: The other skills were scored in the same format to the examples in this round

Second round survey

VALIDATION OF A FUNDAMENTAL MOVEMENT SKILLS SCREENING TOOL FOR 8-12-YEAR-OLD CHILDREN - Second Round.

General Feedback

The expert panel achieved consensus on including the following movement skills:
Locomotor Skills: Leaping, Single-Leg Hop, Vertical Jump, Horizontal Jump, Bodyweight Squat, Walking Lunge.
Balance Skills: Single-Leg Balance Eyes Closed, Two to One-foot Hop and Hold.
The expert panel did not achieve consensus on neither including nor excluding the following movement skills:

Locomotor Skills: Running, Skipping, Dodging, Sliding, Tuck Jump, Forward Roll.
Balance Skills: Single-Leg Balance on Unstable Surface, Single-Leg Balance on Unstable Surface + Catch a Ball, Single-Leg Romanian Deadlift, Single-Leg Squat, Heel to Toe Walking, Single-Leg Sideways Hop and Hold, 90-Degree Jump and Hold, Step-up and Hold on Unstable Surface, Alternate Knee-up and Hold on Unstable Surface, Bird-Dog Exercise.
The items that achieved consensus on being either included or excluded will be indicated within the survey with the green and red colors respectively.

The balance skill "Single-Leg Romanian Deadlift" was renamed "Single-Leg Hip Hinge."

The movement skills “Single-Leg Front Plank” and “Side Plank” and their associated evaluation criteria were suggested by the expert panel and added into the second-round survey.

Introduction

Please score a series of fundamental movement skills and the evaluation criteria associated to each using a 5-point Likert scale (Strongly Disagree [1], Disagree [2], Neutral [3], Agree [4], Strongly Agree [5]).
Consensus on accepting a movement or evaluation criteria is set at 75% agreement (expert panel scores item Agree [4] or Strongly Agree [5]).
Consensus on discarding a movement skill or evaluation criteria is set at 75% (expert panel scores item Disagree [2] or Strongly Disagree [1]).
If consensus is not reached, the movement skill will be included in the next round of the survey.
On the next pages, you will see items previously reaching consensus in green. You will not score these. Items not accepted have a percentage of agreement indicated (i.e. "Toes Pointing Forward (74.1%)"). Any new items suggested from other experts are identified (i.e. "(NEW) Upper-body straight and eyes focused forward").
We want to reach consensus on at least four movement skills from each category (balance and locomotion) and at least four evaluation criteria for each movement skill. If more than eight skills, and four evaluation criteria reach consensus we will ask you to rank the movement skills and/or evaluation criteria.
Please score the evaluation criteria of each skill even if you disagree on including a movement skill. Other skills may reach consensus and the criteria will be important.

(Example.1)

Single-Leg Balance Eyes Closed

The expert panel achieved a consensus on including "Single-Leg Balance Eyes Closed" in the Fundamental Movement Skills screening tool for 8-12-year-old children.
Description:
The child will stand on one leg with the free-knee bent to 45 degrees and free-hip bent to 30 degrees. The child closes their eyes and holds this position for ten seconds.
The child will have two trials on each side.
(Main balance assessment component: Static balance, Sensory integration)

Single-Leg Balance Eyes Closed

Evaluation criteria on which consensus were achieved among the expert panel:

Eyes closed

Foot flat on the floor

Please indicate your level of agreement on whether the following evaluation criteria are appropriate for the movement skill "Single-Leg Balance Eyes Closed" to identify movement patterns that may represent low movement skill competence and/or a risk factor for injury?
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree *

Please choose the appropriate response for each item:

	1	2	3	4	5
Hands on hips (64.3 %)	○	○	○	○	○
(NEW) Upper-body straight	○	○	○	○	○
Legs do not touch (50 %)	○	○	○	○	○
Toes pointing forward (50 %)	○	○	○	○	○
Hold the position for ten seconds (71.4 %)	○	○	○	○	○

Would you like to share any comments about this movement skill and/or the evaluation criteria? (Optional)
Please write your answer here:

(Example. 2)
Single-Leg Sideways Hop and Hold (71.4%)

Please indicate your level of agreement on including the movement skill "Single-Leg Sideways Hop and Hold" in a fundamental movement skills screening tool for 8-12-year-old children.
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree *
Please choose only one of the following:
○ 1
○ 2
○ 3
○ 4
○ 5

Description:
Single-Leg Sideways Hop and Hold is a balance test in which the child tries to recover and keep balance after landing. The child starts by standing on one leg, jumps to the side of the free-leg, lands with the free-leg, and holds the position for three seconds.
The child will have two trials on each side.
(Main balance assessment component: Dynamic balance, Anticipatory postural control)

Single-Leg Sideways Hop and Hold (71.4%)
Evaluation criteria on which consensus were achieved among the expert panel:
Knee and hip bend slightly to land softly in a controlled fashion
Knee and toes aligned
Foot flat on the floor

Please indicate your level of agreement on whether the following evaluation criteria are appropriate for the movement skill "Single-Leg Sideways Hop and Hold" to identify movement patterns that may represent low movement skill competence and/or a risk factor for injury?
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree *
Please choose the appropriate response for each item:

	1	2	3	4	5
Hands on hips (46.1 %)	○	○	○	○	○
Stand up straight within three seconds after landing (61.5 %)	○	○	○	○	○
Toes pointing forward (61.5 %)	○	○	○	○	○
Legs do not touch (61.5 %)	○	○	○	○	○

Would you like to share any comments about this movement skill and/or the evaluation criteria? (Optional)
Please write your answer here:

(Example. 3)
(NEW) Single-Leg Front Plank

Please indicate your level of agreement on including the movement skill "Single-Leg Front Plank" in a fundamental movement skills screening tool for 8-12-year-old children.
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree *
Please choose only one of the following:
○ 1
○ 2
○ 3
○ 4
○ 5
Description:
The child starts with elbows under shoulders, only forearms and toes on the floor, hands clasped together, and feet together. The child will lift one leg until the leg is parallel to the floor and hold the position for five seconds. Repeat on the other leg.
The child will have two trials on each side.

(NEW) Single-Leg Front Plank

Please indicate your level of agreement on whether the following evaluation criteria are appropriate for the movement skill "Single-Leg Front Plank" to identify movement patterns that may represent low movement skill competence and/or a risk factor for injury?
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree*

Please choose the appropriate response for each item:

	1	2	3	4	5
Elbows under shoulders	○	○	○	○	○
Toes on the floor	○	○	○	○	○
Leg parallel to the ground or higher	○	○	○	○	○
No excessive rotation of the upper body and the pelvis	○	○	○	○	○
Back straight throughout	○	○	○	○	○
Straight line from head to ankles	○	○	○	○	○
Holds the position for five seconds	○	○	○	○	○

Would you like to share any comments about this movement skill and/or the evaluation criteria? (Optional)

Please write your answer here:

(Example. 4)
(NEW) Side Plank

Please indicate your level of agreement on including the movement skill "Side Plank" in a fundamental movement skills screening tool for 8-12-year-old children.
[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree *
Please choose only one of the following:
○ 1
○ 2
○ 3
○ 4
○ 5
Description:
The child starts with elbows under shoulders with only the forearms and toes on the floor. Hands should be clasped together and feet beside each other. The child rotates onto the right side supported by the right forearm and right foot with the left foot stacked on the right foot. The child extends the left hand upward while keeping the body in a straight-line. The child will hold the position for five seconds and repeat on the other side.

(NEW) Side Plank
Please indicate your level of agreement on whether the following evaluation criteria are appropriate for the movement skill "Side Plank" to identify movement patterns that may represent low movement skill competence and/or a risk factor for injury?

[1] - Strongly Disagree, [2] - Disagree, [3] - Neutral, [4] - Agree, [5] - Strongly Agree *
Please choose the appropriate response for each item:

	1	2	3	4	5
Elbow under shoulder	○	○	○	○	○
Free-arm extended towards the ceiling	○	○	○	○	○
Straight line from head to ankles	○	○	○	○	○
Whole body rolls over together (linear rotation)	○	○	○	○	○
No pause during rotation	○	○	○	○	○
Stay balanced throughout the movement	○	○	○	○	○
Holds the position for five seconds	○	○	○	○	○

Would you like to share any comments about this movement skill and/or the evaluation criteria? (Optional)
Please write your answer here:

NOTE: The other skills were scored in the same format to the examples in this round

Third round survey

VALIDATION OF A FUNDAMENTAL MOVEMENT SKILLS SCREENING TOOL FOR 8-12-YEAR-OLD CHILDREN - Third Round.

Introduction

This survey contains the movement skills and evaluation criteria that achieved consensus after rounds one and two.
Please rank the movement skills and evaluation criteria to select the top eight movement skills and the top four evaluation criteria associated to each skill.
Please also identify what category you would consider each movement skill. The categories are: 'Locomotor', 'Balance/Stability', 'Both', 'Other'.
Thank you again for participating. Your participation is a great value. Feedback on the first- and second-round results is available upon request.

Movement Skills Ranking

Please rank the following movement skills in order of importance from highest to lowest.
All your answers must be different and you must rank in order.
Please number each box in order of preference from 1 to 10

Running

☐

Leaping

☐

Single-Leg Hop

☐

Horizontal Jump

☐

Vertical Jump

☐

Walking Lunge

☐

Bodyweight Squat

☐

Single-Leg Sideways Hop and Hold

☐

90-Degree Jump and Hold

☐

Two to One-foot Hop and Hold

☐

Evaluation Criteria Ranking

Please rank the following evaluation criteria in order of importance from highest to lowest.
90-Degree Jump and Hold
All your answers must be different and you must rank in order
Please number each box in order of preference from 1 to 6

Stand up straight within three seconds after landing

☐

Toes pointing forward

☐

Whole body turns together

☐

Knee and hip bend slightly to land softly in a controlled fashion

☐

Knee and toes aligned

☐

Foot flat on the floor

☐