Univerzita Palackého v Olomouci
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# THE EFFECTS OF ATTENTIONAL FOCUS INSTRUCTIONS ON PERFORMANCE OF A PERSISTENT FORM-BASED SKILL IN GYMNASTICS

Diplomová práce
(magisterská)

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**Title of the master's thesis:** The effects of attentional focus instructions on performance of a persistent form-based skill in gymnastics

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**Abstract:**

The purpose of this study was to examine the effects of attentional focus instructions on motor performance of a persistent form-based element in children and adults. Participants (six children & six adults), who had previous experience in aerobic gymnastics were asked to perform an L-support task for a duration of 4 seconds in three attentional focus conditions: internal focus, external focus, and control. Two pieces of yellow tape (2×9 cm) were attached to the gymnasts' feet, on internal side of the navicular bones. As such, two pieces of red tape (2×9 cm) were wrapped around the distal phalanx of the big toes of the right and left foot. All participants performed four trials in the external focus (focus on keeping red tapes below yellow tapes), internal focus (focus on pointing your toes), and control (no instructions) conditions. The results showed that execution faults were smaller in an external focus compared to an internal focus and control conditions, regardless of participants' age group. However, no difference was found between an internal focus and control conditions. Additionally, adults had smaller execution faults than children. The findings of this study indicated that an external focus is more beneficial than an internal focus for enhancing motor performance of a persistent movement form-based element, in both children and adults.

**Keywords:** focus of attention, movement form, motor performance, gymnastics.

**Jméno a příjmení autora:** Bianca Maria Gorgovan

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**Abstrakt:**

Cílem této studie bylo ověřit účinek zaměření pozornosti na provedení silové výdrže u dětí a dospělých. Výzkumu se zúčastnilo šest dětí a šest dospělých, kteří se věnovali gymnastickému aerobiku. Tito jedinci prováděli přednos snožmo s výdrží 4 sekundy s odlišným zaměřením pozornosti. Dva kusy žluté pásky (2×9 cm) byly připevněny na chodidla gymnastek, na vnitřní stranu navikulárních kostí. Rovněž dvěma kusy červené pásky (2×9 cm) byly připevněny na distální phalangy palců pravého a levého chodidla. Všichni účastníci provedli čtyři pokusy s vnějším zaměřením pozornosti (soustředění se na udržení červených pásek pod žlutými), čtyři pokusy s vnitřním zaměřením pozornosti (soustředění se na propnutí prstů na nohou) a čtyři pokusy v kontrolních podmínkách (bez instrukcí). Výsledky ukázaly, že technické chyby v provedení u pokusů při vnějším zaměření pozornosti byly menší v porovnání s pokusy s vnitřním zaměřením pozornosti a v kontrolních podmínkách, bez ohledu na věkovou skupinu zúčastněných. Nicméně nebyl zjištěn žádný rozdíl mezi pokusy s vnitřním zaměřením pozornosti a pokusy v kontrolních podmínkách. Dospělí také provedli méně technických chyb než děti. Výsledky této práce ukázaly, že pro zkvalitnění pohybového výkonu prvku založeného na silové výdrži, je vnější zaměření pozornosti více prospěšné než vnitřní zaměření pozornosti, jak u dětí, tak u dospělých.

**Klíčová slova:** zaměření pozornosti, pohybový vzorec, pohybové provedení, gymnastika.

I declare that I have prepared this thesis independently under the supervision of Reza Abdollahipour, M.Sc., Ph.D. I have listed all the literature and professional resources used, and I have adhered to the principles of scientific ethics.

Olomouc……..……...2021

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# Chapter 1

## 1.1. Introduction

### 1.1.1. Strategies for optimizing performance and learning of motor skills

In sports settings, physical practice is a fundamental factor that individuals use for enhancing motor performance and learning. In addition to physical practice, significant interest has been concentrated on comprehending the influential factors that enhance the performance and learning of movement skills. For example, researches have shown that other factors such as conditions of practice, observational demonstrations of the skill, motor imagery ability of individuals, the type of feedback, attentional focus instructions, and motivation have also a substantial influence on performance and learning of motor skills (Schmidt et al., 2018; Soderstrom & Bjork, 2015).

In this regard, research studies have shown that manipulation with conditions of practice such as the amount of practice (e.g., large vs. small practice), practice distribution (massed vs. distributed practice), practice variability (variable vs. constant), practice schedule (e.g., random vs. blocked practice), could play an important role on promoting outcome performance during execution of motor skills (Schmidt et al., 2018). Besides, research suggests that interchanging physical movement and observational methods derive in better learning than a sole observing session followed by rehearsal (Rohbanfard & Proteau, 2011). Moreover, the type and frequency of feedback that performers/learners receive on their attempts to construct an action have been shown to promote performance and learning of new motor skills (Wulf & Lewthwaite, 2016).

In general, there are two types of feedback, inherent feedback and augmented feedback. Inherent feedback involves different sensory structures, such as vision, hearing, proprioceptive and kinesthetic mechanisms, that provide information about the movement and performance outcome before the movement is even completed. Augmented feedback involves information about

performance outcomes provided by an external source of information such as an instructor or a coach. This post-movement information is assigned to the knowledge of results and knowledge of performance which have an impact on upcoming attempts (Mononen, 2007). All these factors have been shown to enhance the performance and/or learning of motor skills. Beyond all these influential factors, attentional focus instructions have remarkably been shown to contribute to successful motor performance and learning (Wulf & Lewthwaite, 2016). In the following sections, the differences between motor performance and motor learning will be introduced, followed by the concept of attentional focus instructions.

#### 1.1.1.1. Motor performance versus motor learning

Research has shown that motor learning and motor performance are the key indicators of individuals' performance enhancement. Yet, it ought to be brought up that motor performance is not the same as motor learning. Researchers have been studying for quite a long time to understand the substructure of skilled performance and the circumstances that influence skill learning. In many ways, motor learning and motor performance are hard to recognize, and yet there are some major and significant differences between these two concepts (Schmidt & Wrisberg, 2008).

Motor performance involves temporary changes in motor behaviour within a single trial or a series of trials in a training session. These temporary changes in motor behaviour are indicators of motor performance, which is the capability of the individuals to perform a motor task. In other words, the act to execute a motor skill results in a temporary change represents the concept of motor performance (Schmidt & Wrisberg, 2008). In contrast, constant/permanent performance changes in motor behaviour over time and in other training sessions indicate motor learning. In fact, motor learning is a relatively permanent change in the ability to carry out a motor skill, as a

reaction to practice and experience (Schmidt et al., 2018). Motor learning cannot be directly observed, and it occurs as a direct effect of practice. Nonetheless, motor learning is an internal process or state that resonates with a person's current competence for producing a skilled action, with gains in memory and relatively permanent gains in performance with practice. Typically, researchers assess motor learning via retention and transfer tests. Retention and transfer tests are very similar for all practical intents as there is an interest in the persistence of the gained potential for performance. The distinction between them is only that transfer tests include persons switching to new tasks or conditions, while the retention tests typically involve retesting people on the same tasks or conditions (Raiola & Di Tore, 2017). In addition to the various effects of motor learning, motor performance has a particularly important role in the study of movement.

Even though a majority of researchers are interested in finding the manipulations that promote motor learning, it is also important to examine the factors that enhance immediate motor performance. Studying motor performance is essential, as the goal of the majority of athletes, coaches, or instructors is to reach optimal performance as quickly as possible. In addition to observing the immediate changes in performance outcome in motor performance studies, researchers can investigate intra-individual differences in performance under different types of manipulations. Therefore, the scope of the current research is about manipulation with different types of verbal instructions on motor performance. Verbal instruction is a key factor for coaches or practitioners to provide necessary information about the movement techniques in communication with a performer. These verbal instructions have been shown to direct the attentional focus of the performer to different aspects of the motor task, which consequently affect performance outcomes (Wulf, 2013). In the next section, the influence of attentional focus instructions on motor performance is presented.

### 1.1.2. Attention and motor performance

Attention has consistently been a subject of significant interest to clinicians and motor behavior analysts. In 1890, William James mentioned in his textbook: “Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others” (James, 1890). After 1910, attention research decreased, while interest and behaviorism bloomed. However, in the 1950s researchers revived their involvement in attention studies, during what has come to be known as the “cognitive revolution”. This permitted unobservable cognitive processes like attention as legitimate objects of scientific study (Baddeley, 2018).

A person’s focus of attention can have a consequential impact on the performance of motor skills. How consistent the outcome or how fluid and accurate the motion is, depends on what an individual directs his or her attention on while performing a motor skill. It has been proved for a long time that paying “too much attention” to the movement may be detrimental, especially when the skill is sufficiently practiced. The question of many researchers often referred to why when we concentrate more on what we are doing, we are prone to make more mistakes than we usually do. Performance cutbacks that appear when we deliberately conduct our attention to the components of our movements are very common. Additionally, new research demonstrates that performance or learning of new motor skills also suffers from directing attention to the coordination of our movements (Wulf & Prinz, 2001). The information about components of the movements or coordination of movement patterns is typically provided through verbal instructions or feedback by coaches or practitioners.

Coaches and instructors use verbal instruction to direct a performer's focus of attention to relevant features of a skill. Adequate and efficient communication between coach and athlete is fundamental for optimal performance. As a result, coaches aim to provide purpose and efficient techniques for enhancing the execution of a motor skill. By directing an individual's attention to a precise focus, they can influence the athlete's thought process in the achievement of a task. If effective, this focus of attention will grow into the motif of mental concentration instead of just a transient thought. Focus of attention can be presented as either internal or external. An internal focus instruction is introduced as focusing on body-related movements' techniques such as position or speed of the arm, hands, feet, and body. Internal focus instructions tend to direct the athlete's focus of attention to step-by-step execution of an action or movement technique. On the other hand, an external focus instruction aims at focusing on the movement-related outcomes, elements outside the body, such as implements, surfaces, a target, or the trajectory of an object or the environment. Over the past two decades, numerous researches have been carried out on the influence of the two types of internal versus external attentional focus on motor performance or learning, in various motor tasks and different contexts in adults.

In this regard, a large body of research has supported the advantages of an external relative to an internal focus on motor performance in adults (for a review see Wulf, 2013). In the first study, Wulf et al. (1998) carried out an experiment with a ski simulator to examine the influence of attentional focus instructions on motor performance and learning. In this study, learners in the external focus group were instructed to keep the balance by focusing on putting pressure on the wheels of a platform on which they were standing. For the internal focus, on the other hand, participants were asked to apply force with their feet. No focus instructions were given to the control group. The external-focus instructions group enhanced learning to a greater extent

compared with the results of internal-focus instruction and no instructions. Since then, various experiments conducted on the effectiveness of an external relative to an internal focus on motor performance or motor learning in different types of motor tasks. As the scope of the current study is on motor performance, only literature on the influence of attentional focus instructions on motor performance in the healthy population is introduced.

Particularly, research on healthy adults has shown that external focus is more beneficial than an internal focus for enhancing motor performance in various types of motor tasks that involve and do not involve an implement. For example, the external focus is more beneficial than the internal focus in motor tasks using an implement such as the balance on stabilometer (Wulf et al., 2001; Wulf et al., 2001; Wulf et al., 2003), standing still on rubber disk task (Wulf et al., 2004), balance task on Balance Master (Landers et al., 2005), golf chip shot task (Bell & Hardy, 2009), golf putting task (An et al., 2013), dart-throwing task (Lohse et al., 2010; Marchant et al., 2007), playing the piano (Duke et al., 2011), pressing barbell (Marchant et al., 2011).

Likewise, an external relative to an internal focus instruction promoted the motor performance of motor tasks that did not involve an implement such as vertical jump-and-reach task (Wulf et al., 2010), swimming (Stoate & Wulf, 2011; Freudenheim et al., 2010), standing long-jump task (Porter et al., 2010) or a cyclic one-leg extension-flexion task (Kal et al., 2013).

A minor body of research did not find any advantages for an external versus the internal focus of attention in adults for motor tasks that involve an implement. For example, Perkins-Ceccato et al. (2003) reported that participants in a golf pitch shot task benefit from an internal relative to an external attentional focus for low-skilled golfers. In another study, Schorer et al. (2012) did not find any evidence to support the advantages of an external relative to an internal focus of attention in a dart-throwing task.

Overall, a large body of research has shown that movement efficacy improved by using an external relative to an internal focus instruction (see Wulf, 2013). That is, the external focus was more beneficial than internal focus by enhancing both immediate motor performance in adults for different motor tasks that involve and do not involve implement. Although an external relative to internal focus has extensively been compared in adults, a few studies have examined the link between the focus of attention on immediate motor performance in children. In the next section, the findings on studies on the effectiveness of an external relative to an internal focus on motor performance in children are presented.

#### 1.1.2.1. Focus of attention and motor performance in healthy children

Children differ from adults in certain characteristics, including the competence to regulate their attentional focus. Therefore, researchers have examined the influence of attentional focus instructions on children's motor performance. The majority of these research studies have been conducted on the motor tasks that involve an implement.

For example, Abdollahipour and Psotta (2017) examined the effects of internal and external focus instructions on the motor performance of a catching task in children. Twenty-four healthy children (*M*age: 8.75 years, *SD* = 0.79 years) from elementary schools participated in this study. All children performed a two-handed catching of the tennis balls task thrown by a tennis ball machine. 30 trials were performed in a within-subject design, 10 under each attentional focus condition: external focus, internal focus, or control conditions. The findings showed that promoting the external focus instructions on the flying ball was more beneficial to reach optimal performance than internal focus on hand movements in an interceptive motor task in children.

In another study, researchers examined the effects of internal and external attentional focus cues on children's motor performance during object control motor skills (Palmer et al., 2017). Twenty boys and twenty-four girls with an average of 7.7 years performed the task under three attentional focus conditions. The motor skill assessment consisted of the object control subscale of the Test of Gross Motor Development. This evaluation demonstrates a child's ability to achieve six major motor skills – striking a static ball, stationary dribble, catch, kick, throw over the hand, as well as underhand roll. The object control subtest was completed by all children under three attentional focus conditions: control, internal and external. Findings revealed that children had better performance in the external focus of attention relative to baseline than no instructions at all. These results align with the literature and maintain the concept by which external focus of attention has a positive effect on motor performance.

A research study by Abdollahipour et al. (2017) analysed the combined effects of external focus instructions on motor performance. Thirty-six children (*M*age: 8.5 years; *SD* = 1.3 years) performed a bowling-related task with their dominant hand under three attentional focus conditions. A manipulation inspection was conducted after executing 8 throws in each focus condition and a video was projected when participants began the bowling throw. A different video with a gorilla was projected on an extra trial when subjects started their bowling motion. Children were asked whether they noticed anything. Participants detected fewer differences between videos in the external focus compared with internal or control conditions. The findings suggest that external focus of attention leads to a higher throwing accuracy, relative to both internal focus and control conditions.

In one study, van Abswoude et al. (2018) reported that both internal and external focus were beneficial for enhancing the motor performance of a golf-putting task. Twenty-five children

aged 8 to 12 years old (*M*age: 10.4 years; *SD* = 1.1 years) performed a golf putting task on artificial grass. In addition to internal and external focus conditions, working memory capacity and conscious motor control were assessed. Randomly assigned, the children performed 10 practice trials under the external or internal focus of attention, with one week between sessions. The average distance toward the hole was assessed in 3 blocks of 10 trials. Participants were instructed to move their arms like a pendulum (internal focus) or to move the golf club like a pendulum (external focus). The findings of this study showed that children can benefit from both internal and external focus to improve short-term motor performance. Researchers highlighted the importance of individual differences in children's motor performance.

Studies on healthy children have also shown advantages an external relative to an internal focus for enhancing the motor performance of the tasks that do not involve an implement. For example, Moreover, Marchant et al. (2018), examined the effects of attentional focus on motor performance of children in two independent standing long jump experiments. The first experiment aimed to assess whether young children (*M*age: 7.35 years; *SD* = 1.7 years) as adults benefit from advantages of external relative to internal attentional focus instructions when executing a standing long jump. Twenty-three male and twenty-one female children participated in this experiment. The results showed that children would benefit from external relative to internal focus instructions for jumping task. In the second experiment, researchers examined if children as adults would also benefit from distal external attentional focus instructions relative to a proximal external focus of attention. Fifty-four children attended this experiment. None of them was a novice in jumping, but they had no previous experience of the standing long jump test. Preceding each jump, specific attentional focus instructions were addressed to all children. Performance advantages were found when a greater distance of movement effect was accentuated. External focus instructions

contribute to children's jump performance, especially when they are sustained by a movement goal. Both experiments underline the benefits of adopting an external focus of attention by verbal instruction directed to children when executing movements.

Shin et al. (2019) analysed the effects of an internal and external focus of attention on postural balance in school-aged children in a cross-sectional study. Twenty-four healthy children with an age range from 8 to 12 years old participated in this study. The examiner used a force plate to assess postural balance during the one-legged standing posture. In this study, all participants completed the control condition first. For the external focus conditions, subjects were told to stand on one leg by focusing on the markers arranged in front of them. The present study evaluated the range, distance, and velocity of the center of pressure during one-legged standing external, internal, and control conditions. External focus of attention was found to promote automatic information processing of motor skills. On the other hand, the external focus did not have a stronger effect than the internal focus on postural sway. The authors proposed that this may be since school-aged children go through a transitional stage from internal to external focus in effective motor performance and learning.

Ashraf et al. (2017) examined whether movement efficacy and efficiency of children's motor performance are influenced by the external focus of attention. Twenty healthy boys aged around 9 years old (*M*age: 9 years; *SD* = 0.94 years) took part in this study. The task was to execute the vertical jump-and-reach test, by touching the highest rung possible with the dominant hand. In the internal focus conditions, children were asked to focus on the tips of their fingers. In the external focus conditions, children were asked to focus on the rungs. In control conditions, no attentional focus instructions were given. The findings showed that children jumped higher in the

external relative to internal focus condition. Also, lower EMG activity resulted when the boys focused externally on the rings, compared to focusing on their fingertips.

Psotta et al. (2020) analysed the effects of attentional focus instructions on the performance of a whole-body coordination task in typically developing children with developmental coordination disorders. Three countermovement vertical jumps in the internal focus of attention, external focus, and control conditions were performed by eighteen children with developmental coordination disorder and twenty-one typically developing children. Participants were aged between 9 and 10. Despite the children's motor development proficiency, both jump height and take-off velocity were higher in external focus conditions relative to control conditions or even internal focus. The results of this paper illustrate how the external focus of attention in comparison to internal focus instructions could intensify the neuromuscular activation of dynamic contractions of the leg muscles in both children suffering from developmental coordination disorder or typically developing children. This research demonstrates the benefits of an external focus of attention relative to an internal focus on motor performance across children with particular motor proficiency levels.

To our knowledge, only one study did not show the superiority of an external relative to an internal focus on enhancing the performance of motor tasks that did not involve an implement. Chow et al. (2014) included thirty-six children in a study regarding coordination in children and the effects of instructional constraints on task performance. Participants executed a two-footed standing broad jump test on a mat. Maximum jump distance was assessed at each attempt and 15 infrared cameras captured kinematic data. Task performance outcomes were determined from the jump distance reached by each subject. Also, a questionnaire was administrated to all children as a form of manipulation check and children indicated that the instructions were useful during

practice sessions. The pedagogical demand is to provide the most opportune instructions. Teachers and instructors may increase children's levels of performance and learning from simple adjustments in the instruction's words. The impact of an internal or external focus of attention on children differs as compared to adults. This difference in focus instructions is worth analysing future cases.

In sum, an extensive body of research conclusively supports the notion that an external focus is more beneficial than an internal focus for enhancing performance outcomes in motor tasks that involve or do not involve an implement in both adults and children. Yet, only a few studies have been carried out on motor tasks that both performance outcome and movement form are important. Following, the influence of attentional focus instructions on movement form is presented.

#### 1.1.2.2. Focus of attention and movement form

The influence of attentional focus on motor tasks that require movement form has been an outstanding question for researchers within past years. On one hand, it is quite difficult to find an external cue for motor tasks that require movement form. On the other hand, the evaluation of these motor tasks is based on perfect movement form. That is, the majority of instructions are referenced to body movements or movement techniques. These body-related instructions tend to promote an internal focus of attention, which may not produce optimal performance outcomes. In this regard, a few studies have examined the influence of attentional focus instructions on motor tasks that require assessment of movement form (Abdollahipour et al., 2015; Lawrence et al., 2011).

In the first study on adults, Lawrence et al. (2011) measured motor performance on accurate movement form and analysed the optimal focus for novices during a movement series. Forty participants (*M*age: 20.3 years; *SD* = 1.6 years) with no gymnastics experience were guided to practice a floor gymnastics routine, after watching a short video of an expert. The routine was composed of five simple movements, including a starting and final pose. Subjects were divided into four attentional groups: external, internal relevant, internal irrelevant, and control group. For the external focus conditions, participants were asked to focus on the movement pathway and to exert an even pressure onto the support surface. On the internal relevant focus group, for example, adults had to focus on exerting equal force on their feet, while keeping their arms straight, in line with their shoulders. The findings indicate that external focus instructions might not be opportune to generate the correct movement form for a gymnastics routine. These results are expected, taking into consideration the instructions relative to the complexity of the task and evaluation system. Instructions were completely irrelevant to most aspects of the routine. Therefore, more appropriate instructions would have resulted in a typical attentional focus effect (Wulf, 2013).

Guss-West and Wulf (2016) analysed the effects of attentional focus on skilled motor performance among professional ballet dancers. Fifty-three participants, current or former dancers, filled out an online survey consisting of four questions. Increased motor complexity was the criterion for formulating the questions: sustained balance on two-foot, sustained balance on one-foot, dynamic balance with more complex rotation from one foot, and explosive long jump. Two investigators divided the registered answers using three divisions: internal focus of attention, external focus of attention, and combination of internal and external focus. About three-quarters of the answers referred to body movements, internal focus, and combination. Only 28 % reported external focus-related responses. This study concludes that a better wording formulation in

instructions, as well as a more distal external image would have a lasting effect on the unceasing technique. The authors suggested that immediate benefits would be noted when teachers and dancers would use creativity to adopt appropriate external focus instructions.

Only one study was conducted on a motor skill that requires assessment of movement form in children. In contrast with researchers using an implement to demonstrate the effects of an external focus of attention, Abdollahipour et al. (2015) assessed a gymnastics skill that did not concern the adoption of any implement. Twenty-two girls and two males, all gymnasts, took part in the experiment. The sportsmen had experience competing at the Czech national level, but they weren't aware of the purpose of the study. Participants were aged 12 and they executed a 180-degree turn while airborne vertical jump under three different focus conditions. Unlike other previous studies, the assessment of movement quality represented an important aspect of the present paper. A tape marker was attached to the gymnasts' chest, and participants were asked to focus on its direction after the turn, during the external focus conditions. Under the internal focus conditions, they were asked to focus on their hands' direction that was crossing their chest, and no focus instructions were given to the control group. The findings suggest both superior movement form and greater jump height under the external focus conditions in comparison with internal or no focus instructions. This study appears to be the first one to demonstrate how a form-based sport skill benefits from an external focus of attention. A possible limitation identified in this study regards the attention focused on the hands crossing in front of the chest and not the chest itself during the internal focus condition. This study provides an excellent example for assessing motor performance on different attentional conditions without involving an implement which appears to be a challenge.

## 1.2. Purpose of this study

The purpose of the current research was to examine the effects of internal versus external focus of attention on motor performance of a motor task that does not involve an implement and requires persistent movement form in gymnastics in children and adults. Particularly, in the current study the effects of external versus the internal focus of attention on motor performance of an L-support motor task which is an isometric strength task, and requires not only balance and strength, but also persistent movement form was examined.

### 1.2.1. Research hypotheses

The following hypotheses were proposed within the framework of the study:

Hypothesis 1: An external relative to an internal focus instruction improves the motor performance of a persistent movement form-based skill in both children and adults.

Hypothesis 2: Adults perform better than children in a persistent movement form-based skill, regardless of attentional focus instructions.

# Chapter 2

## 2.1. Methods

Detailed information about the participants, study design, procedure, measures, instruments, materials, and analyses have been described in this chapter. The subjects' characteristics are presented next.

### 2.1.1. Participants

Twelve female gymnasts in the age range from 9-22 years old, six children (*M*age = 10.1 years, *SD* = 1.16 years), and six adults (*M*age = 19.1 years, *SD* = 2.63 years) participated in the present study. All subjects were experienced aerobic gymnasts, with an average training experience of *M* = 5.83 years, *SD* = 1.72 years in children and *M* = 13.33 years, *SD* = 3.66 years in adults. All participants were healthy. They were recruited from the Corridoor sports club, aerobic gymnastics section, in Prague, Czech Republic. Informed consent was collected from the subjects or their legal delegate before the data collection. Their current training program consisted of 3 to 5 sessions of 2 to 3 hours per week. Most of the girls had experience competing at the Czech national level, and four of them represent the Czech Republic national team in international competitions. Both children and adults did not know the particular objective of the study.

### 2.1.2. Task and apparatus

The task was to hold the position of L-support, aerobic gymnastics element, on a mini portable parallel bar. The element's beginning position is seating with legs near one another, and hands are put along the side of the body near to the hips. The body is upheld by the two arms with just the hands in contact with the smaller portable parallel bar. Hips are flexed and legs should be held

parallel to the floor throughout the task (see Figure 1). Participants were barefoot. The skill required not only isometric strength of the hip flexors, musculus rectus femoris, abdominals, and obliques, but also balance and high precision (alignment, feet, toes, and back position), as any imperfection is taken into account as deduction (see Table 1). The height of the mini portable parallel bar was 25 cm. The width of the parallel bar was 22 cm and its length was 35 cm.

**Figure 1**

*Schematic L-support motor task*

The experiment was realized in a room between 4 and 5 $m^2$. All trials were recorded by two video cameras that were mounted onto tripods. One camera was set up on the diagonal front side of the subjects and the second one on the left side of the mini portable parallel bar, both at a 1-meter distance. The purpose of the recordings was to help the raters to check the execution scores of particular trials, in case there was more than 0.1 difference between the two raters. Two pieces of yellow tape (2×9 cm) were attached to the gymnasts' feet, on the internal side of navicular bones. Two pieces of red tape (2×9 cm) were wrapped around the distal phalanx of the big toes of the right and left foot (see Figure 2). These tapes served as the attentional cue in the external focus condition.

**Figure 2**

*External cues represented by red and yellow tape*

### 2.1.3. Procedure

The subjects were asked to be barefoot at the beginning of the experiment and coloured tapes were added accordingly, as presented earlier. Then, participants were instructed to look at one picture representing the L-letter shape and an L-support technical representation provided by the Aerobic Gymnastics 2017-2020 Code of Points (de Gymnastique, F. I. Aerobic Gymnastics 2017–2020 Code of Points. 2017). A verbal summary of the task by an experimenter was used in the visual picture. The verbal description included the L-position with legs together held above the floor and the back being straight and aligned with the head being upright. This information was identically presented to all subjects.

Participants completed a practice trial after ensuring that they understood the instructions and before data collection began. All gymnasts performed four trials in external focus (EF), internal focus (IF), and control (Con). The order of performance was counterbalanced as follows: IF, EF, Con; EF, Con, IF; Con, IF, EF; IF, Con, EF; EF, IF, Con and Con, EF, IF. The requirement was to hold the L-support for 4 seconds. Rest intervals were provided for 20-second between trials and 3-min between focus conditions. During the 20-second break, participants were given relevant instructions, depending on which condition was coming next. In the external focus conditions, subjects were asked “to focus on keeping red tapes below yellow tapes”. In the internal conditions, participants were instructed “to focus on pointing their toes”. No focus instructions were given to the control group. No feedback about the performance was provided for the gymnasts.

A manipulation check was administrated after completing 4 trials in each attentional focus setting. At the end of every 4 trials, participants were asked: “What did you focus on?”. The subjects were asked to indicate, on a scale from 1 (not at all) to 10 (very much), “how much did you focus on…?”. At the end of all 12 trials under the 3 focus conditions, the subjects were asked

to indicate the level of task difficulty, on a scale from 1 (not at all) to 10 (very much). No input on their results was explained to the participants. At the end of the experiment, the investigators thanked the gymnasts for participating in this study.

### 2.1.4. Dependent variables

The dependent variable is represented by the participants' motor performance, indicated by the average execution scores on movement form in each attentional focus condition. The motor performance of L-support was evaluated by two gymnastics specialists. Each rater assessed each L-support execution conform the criteria, element pool, and values of the FIG-COP (2009) for aerobic gymnastics. Principally, deductions were added up for uncontrolled feet position, legs/feet bent or apart, incorrect body alignment, rounded back position, and legs not parallel to the floor (see Table 1). The judges' scores for each trial were promoted as a measure of movement form, representing a qualitative measure. The judges then compared their performance execution error scores and found compromise where there was an inconsistency. For each mistake, deduction points were listed as follows: small error 0.1, medium error 0.2, major error 0.3, and/or unacceptable error 0.5.

**Table 1**
*General and specific execution points from the Fédération Internationale de Gymnastique code of points for aerobic gymnastics (2009).*

| Execution faults | Judging criteria | Small | Medium | Large | Unacceptable |
|---|---|---|---|---|---|
| | | 0.1 | 0.2 | 0.3 | 0.5 |
| Incorrect body alignment | Upper body position, arms and shoulders placement and neck relative to the spine | 1 part | 2 parts | 3 parts | 4 parts or more |
| Incorrect body form | L-shape body form, back and legs position with hips flexed at 90° | 1 part | 2 parts | 3 parts | 4 parts or more |
| Legs not parallel to the floor | Positioning of the legs parallel to the floor throughout the task | 10° | 20° | 30 ° | 40° |
| Legs/ feet bent | Positioning of the feet relative to the knees and hip joint | <5 cm | 5-10 cm | 10-15 cm | > 15 cm |
| Legs/ feet apart | Feet have to be together throughout the task | <5 cm | 5-10 cm | 10-15 cm | > 15 cm |

### 2.1.5. Data analysis

L-support execution scores were averaged across 4 trials and analysed using a 2 (age groups: children vs. adults) x 3 (attentional focus conditions: EF, IF, Con) analyses of variance (ANOVA) with repeated measures on the last factor. The assumptions of normality were tested using the Shapiro-Wilk test. The data were normally distributed for all attentional focus conditions ($p > .05$). Mauchly's Test was used to test the assumption of sphericity ($\chi 2(2) = 5.598$, $p = .061$). The Bonferroni test and adjustments were used in all post-hoc comparisons. Estimates of effect size were calculated using two measures. First, partial eta squared ($\eta p2$) was utilized where $\eta p2 = 0.01$, 0.06, and 0.14 were estimated for a small, moderate, or large effect, respectively (Lakens, 2013). The Cohen's d was employed as a measure of the difference between focus conditions in within-subject designs that also takes into account the correlation between the two means (Morris & DeShon, 2002). The evaluation of Cohen's d corresponded to low ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) effects (Cohen, 1988).

Inter-rater reliability in assessing the movement execution scores between two judges was determined using intra-class correlation (ICC) analysis based on a two-way mixed-effects, absolute agreement parameters (Shrout & Fleiss, 1979). The coefficient values of <.50, .50-.74, .75-.90, and >.90, were indicating poor, moderate, good, and excellent correlation, respectively (Portney & Watkins, 1993). A non-parametric Mann-Whitney U test was used to compare the intensity of task difficulty between children and adults. The level of significance was set at $\alpha$ =.05 for all statistical tests. Analyses of data were provided with the Statistical Package for the Social Sciences, SPSS 21.

**2.2.Results**

*Manipulation check*

Participants' responses to the questions in the manipulation check indicated children adhered to the external focus and internal focus instructions to a great extent (see Table 2). Although some children reported the use of other foci, the majority of those cues were external or internal in the external focus versus internal focus conditions, respectively. In the control condition, a relatively large proportion of cues were internal in nature. Children's ratings on the "intensity" of foci ("How much did you focus on it?") were relatively high (see Table 2). There was no significant difference among different focus conditions on intensity of foci, $F(1.294, 29.754) = 0.562$, $p = .503$, $\eta\rho 2 = 0.024$.

**Table 2**

*Participants' responses to the questions in %, "What did you focus on?" in percent, and "How much did you focus on it?" (Likert scale from 1 to 10) in different attentional focus conditions.*

| | Control | | Internal focus | | External focus | |
|---|---|---|---|---|---|---|
| | "What did you focus on?" | "How much …? | "What did you focus on?" | "How much …? | "What did you focus on?" | "How much …? |
| Reported external foci | | | | | | |
| Red tape below yellow tape | - | - | - | - | 50 | 8.50 |
| Red tapes being together | - | - | - | - | 8.33 | 8 |
| Red tapes | - | - | - | - | 8.33 | 9 |
| Tapes together | - | - | - | - | 8.33 | 7 |
| Tapes together and red below yellow tape | - | - | - | - | 8.33 | 8 |
| On holding L-shape/L-support | 16.67 | 7.50 | - | - | - | - |
| Total | 16.67 | - | - | - | 83.33 | - |
| Average | - | 7.50 | - | - | - | 8.1 |
| | | | | | | |
| Reported internal foci | | | | | | |
| Feet together and pointing toes | 8.33 | 10 | 25 | 8.33 | - | - |
| Pointing tips of toes | 8.33 | 9 | 16.67 | 8.50 | - | - |
| Tips of toes | - | - | 25 | 9 | 8.33 | 3 |
| Keep the legs together and keep them in the air | - | - | 8.33 | 9 | - | - |
| Straight body | - | - | 8.33 | 4 | - | - |
| Straight legs & body | 8.33 | 9 | - | - | - | - |
| Legs and back | - | - | 8.33 | 10 | 8.33 | 10 |
| Feet together | 8.33 | 9 | - | - | - | - |
| Feet | - | - | 8.33 | 8 | - | - |
| On lifted legs | 8.33 | 8 | - | - | - | - |
| Rise legs a bit up | 8.33 | 5 | - | - | - | - |
| Contracting abdominal | 8.33 | 10 | - | - | - | - |
| Straight back and pointing tips of toes | 8.33 | 9 | - | - | - | - |
| Straight legs | 8.33 | 8 | - | - | - | - |
| Total | 75 | - | 100 | - | 16.67 | - |
| Average | - | 8.56 | - | 8.12 | - | 6.50 |
| | | | | | | |
| Other foci | | | | | | |
| Not to sit on the bar | 8.33 | 9 | - | - | - | - |
| Pass | - | - | - | - | - | - |
| Nothing | - | - | - | - | - | - |
| Total | 8.33 | - | - | - | - | - |
| Average | - | 9 | - | - | - | - |

*Inter-rater reliability*

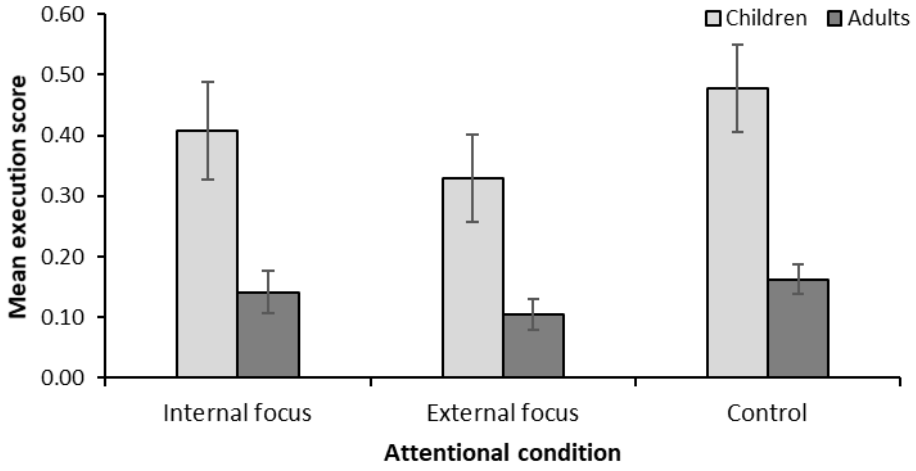
The average measure ICC for execution scores in all trials was $r = .905$, 95% *CI* (.807, .931), $p < .001$, indicating an excellent inter-rater reliability between two judges.

*Movement form*

Figure 3 shows the mean execution scores for movement form across trials under the different attentional focus conditions. The results revealed that the main effect of attentional focus condition, $F(2, 20) = 17.953$, $p < .001$, $\eta p2 = 0.642$ was significant. Bonferroni Post-hoc test showed that the movement form for L-support in the EF ($M = 0.217$, $SD = 0.17$) was significantly better than in the IF ($M = 0.275$, $SD = 0.20$, $p = .001$, $d = 1.37$) and control ($M = 0.320$, $SD = 0.20$, $p < .001$, $d = 1.46$) conditions. No significant differences were observed between IF and control condition ($p = .197$, $d = 0.60$).

**Figure 3**

*Mean execution scores for movement form in attentional focus conditions in children and adults*




*Note.* Error bars represent standard error and are calculated on the basis of within-participant error with the method provided by Masson and Loftus (2003).

Also, the main effect of age group showed that the movement form for L-support was significantly better in adults ($M$ = 0.136, $SD$ = 0.07) relative to children ($M$ = 0.405, $SD$ = 0.18, $F(1, 10) = 12.005$, $p = .006$, $\eta p2 = 0.546$) (see Figure 3). The interactions between attentional focus and age group just failed to reach statistical significance, $F(2, 20) = 3.373$, $p = .055$, $\eta p2 = 0.252$.

# Chapter 3

## 3.1. Discussion

The purpose of the current study was to examine the effectiveness of attentional focus instructions on motor performance of a form-based gymnastics element in children and adults. The results of this study showed that the advantage of external over the internal focus of attention was found in both children and adults in a persistent movement form-based element. These findings suggest that external focus of attention enhances the motor performance of a form-based element in gymnastics regardless of the gymnasts' age group.

These findings are consistent with previous studies which have shown that adults and children benefited from external focus compared to an internal focus of attention in other form-based elements such as jump and ½ turn in children gymnasts (Abdollahipour et al., 2015), sustained balance on two-foot, sustained balance on one-foot, and dynamic balance with more complex rotation from one foot and explosive long jump in adults ballet dancers (Guss-West & Wulf, 2016). Also, the current finding is in line with previous studies that have shown the advantages of an external over the internal focus of attention in the motor tasks that do not involve an implement, such as vertical jump-and-reach task (Wulf et al., 2010), swimming (Stoate & Wulf, 2011), standing long jump (Marchant et al., 2018), one-legged standing posture (Shin et al., 2019). Overall, the findings support the notion that beneficial effects of an external relative to an internal focus could be expanded to those motor tasks that do not involve an implement and/or require temporary/persistent movement form, regardless of age group.

The absence of effects for an external relative to internal focus instruction in the study by Lawrence et al. (2011) might be related to the complexity of the task (e.g., five-part gymnastics floor routine) and the content of instructions (Abdollahipour et al., 2015). For instance, external

focus instructions related to "focusing on the movement pathway and on exerting an even pressure on the support surface". On the other hand, the internal focus instructions were related to "focusing on exerting an equal force on their feet, keeping their arms out straight, level with their shoulders" (Lawrence et al., 2011, p. 434). Essentially, to compare the effectiveness of attentional focus instructions on motor performance, it has been recommended that the differences in the content of instructions should only be *one* or *two words* (Abdollahipour et al., 2015; Wulf, 2013). Also, the content of attentional focus instructions, in essence, should be relevant to the motor task. When attentional focus instructions are vague, extensive, and irrelevant to many aspects of the motor task, the effectiveness of attentional focus instructions is not comparable (Abdollahipour et al., 2015). Our findings are following existing evidence that has shown only 1 or 2-word differences in attentional focus instructions (e.g. the marker versus hands) was enough to trigger the effect, as demonstrated in prior studies (Abdollahipour et al., 2015).

A lack of research incorporating skills that do not require an implement, to which focus could be directed, caused some researchers to believe that various skills in gymnastics, dancing, or swimming could benefit from an internal focus of attention (Wrisberg, 2007). Nevertheless, the findings of our current study and previous studies on motor tasks that do not involve an implement and require movement form suggest that the performance of such motor skills could also improve by an external attentional focus, that is comparable with the beneficial effects of external focus instructions for other motor skills that involve an implement (see Wulf, 2013).

Numerous previous studies have also shown the beneficial effect of an external relative to an internal focus of attention on motor performance in both adults and children in the motor tasks that involve an implement (see Wulf, 2013). For example, research on adults has demonstrated that an external focus is more beneficial than an internal focus for enhancing motor performance

in various tasks using an implement, such as golf chip shot task (Bell & Hardy, 2009), dart-throwing task (Lohse et al., 2010), golf putting task (An et al., 2013), pressing barbell (Marchant et al., 2011). As such, children benefited from external relative to internal focus instruction in the motor tasks that involve an implement including a two-handed catching of the tennis balls task (Abdollahipour & Psotta, 2017), object control motor skills (Palmer et al., 2017), bowling related task (Abdollahipour et al., 2017), golf putting task (van Abswoude et al., 2018). Therefore, the effectiveness of an external relative to an internal focus of attention is shown to be independent of the age group, in a variety of tasks that involve an implement.

Also, the findings of the current study showed that while there was no difference in performance outcome between the internal and control conditions (when no instruction was given), an external focus of attention was better than the control condition. This finding of the current study on the L-support task is identical with the finding of the previous study on the jumping task (Abdollahipour et al., 2015), as movement form was enhanced in the external focus compared to the control condition. The results of the post-interview questionnaire showed that the majority of participants in the control condition (when no instruction was given) tended to focus on their body movements (Land et al., 2013; Pascua et al., 2014; Porter et al., 2010). The results of the post-interview are a piece of new evidence that shows participant's thought process in the control condition is to some extent identical to the internal focus condition, specifically, in the movement form-based elements. Therefore, it could be suggested that both internal and control conditions promoted internal focus thoughts, which resulted in increasing the number of deductions and poor body shape or alignment, regardless of the age group.

Together, the findings of the current study and previous research provide a more comprehensive perspective to the primary picture related to the effectiveness of an external relative

to an internal focus of attention. That is, advantages associated with the effectiveness of an external relative to an internal focus of attention on motor performance are independent of the motor task characteristics including the tasks with and without using an implement or the tasks that require or do not require movement form. Moreover, the benefits associated with implementing an external relative to an internal focus could be generalized across different age groups including children and adults (see Wulf, 2013).

*Attentional focus and immediate motor performance*

While motor learning studies assess the effectiveness of long-term intervention programs, motor performance studies typically measure immediate changes of interventions/manipulations on performance outcomes. Essentially, in addition to examining the immediate changes in performance due to manipulation/interventions, it is also possible to explore intra-individual differences in performance outcomes. In the studies on attentional focus, research has demonstrated that an external focus of attention has an immediate impact on the performance outcomes of motor tasks compared to an internal focus of attention in tasks without using an implement in adults (Wulf et al., 2010; Stoate & Wulf, 2011; Freudenheim et al., 2010), and in children (Marchant et al., 2018; Shin et al., 2019; Psotta et al., 2020; Chow et al., 2014).

The results of the current study showed that an external focus has an immediate impact on enhancing performance outcomes as compared to an internal focus of attention in a task that does not depend on using an implement and also requires movement form. As movement form is the key element in determining individuals' levels of motor performance, it is essential to identify appropriate instructions which have an immediate impact on corrections of movement forms. Abdollahipour et al. (2015) have already reported the performance advantages of an external

relative to an internal focus of attention in children. The findings of the current research suggest that not only children but also adults with previous experience in training gymnastics could benefit immediately from the advantages of an external relative to an internal focus instruction to correct their movement form, leading to improve movement outcome. These results suggest that the effectiveness of an external relative to an internal focus of attention on enhancing performance outcome is immediate in both children and adults, considering intra-individual differences.

*Mechanism*

The aim of the current study was not to investigate the underlying mechanism of attentional focus instructions, yet, our findings suggest that in those motor skills that do not involve an implement (e.g., movement form-based elements) using metaphors might be replaced. Essentially, as previously suggested, "metaphors can serve the same purpose as they provide a mental image of the movement goal that the performer can try to produce without directing attention to body movements per se" (Abdollahipour et al., 2015). In other words, directing attentional focus at body-related movements or execution techniques may prevent optimal performance outcomes (McKay et al., 2015). Essentially, less than optimal performance outcome in an internal focus condition is due to increasing excessive self-concentration that disrupts automaticity of movement control, which transmits noise to the motor system, thus diminishing optimal performance outcome. Therefore, focusing on body movements prevents participants from an optimal focus on the task goal and maximizing performance outcome.

To date, the possible explanation for the benefits of an external focus of attention is proposed in the constrained action hypothesis (Wulf et al., 2001). According to this hypothesis, the internal focus of attention disrupts automatic control by augmenting conscious control of

muscle activity, leading to blockage of optimal motor skills execution. External focus of attention, on the other hand, encourages more automatic methods of motor control, by reducing conscious attentional demands. In other words, successful motor performance outcome is achieved by focusing on the movement effects (Peh et al., 2011). Several experiments have found that external focus increases motion facility, which represents an indicator of movement automaticity, supporting the constrained action hypothesis (Kal et al., 2013).

*Motor performance of children vs. adults*

The results of the current study showed that adult gymnasts perform better than children gymnasts, regardless of attentional focus instructions. That is, the performance of a persistent movement form-based element, was better in adults relative to children, regardless of any given verbal instructions. This finding is not surprising due to the differences between adult gymnasts and children gymnasts in balance, muscular strength and endurance, motor memory, and the amount of experience in structured training.

Many researchers examined the motor performance of a balance task in children and adults. Optimal balance performance was analysed by Cherng et al. (2001) in a study including seventeen children and seventeen adults. The lower performance of standing balance was recorded in children versus adults. The findings showed that the vestibular system's functional adaptation was still evolving in children and has not reached the level of adults. This may explain their inferior operation of the sensory organization and lower balance performance in children in comparison with adults. Also, the ankle plantar, dorsiflexor muscles and their utility in balance tasks are under development in children, amplifying the differences in the performance of balance tasks in children versus adults.

Muscular performance qualities, such as strength and endurance vary significantly between children and adults (Dotan et al., 2012). Some studies compared the performance between adults and children in different tasks. For example, Falk et al. (2009) have demonstrated that maximal muscle force is lower in children than in adults in a study with fifteen children and sixteen adults. During an isometric elbow flexion and extension task, adults were substantially stronger than children in absolute terms, as predicted. Another study analysed the muscle strength of isometric elbow flexion in female children versus female adults. The variations of age-related isometric strength appeared to be primarily determined by muscle size (Falk et al., 2009). Therefore, muscle strength and endurance could potentially be one of the reasons for differences between the performances of adults versus children.

Differences in the development of motor memory and memory retrieval may also play an important role in differences in motor performance and motor learning between the age groups (Thomas, 1980; Chi, 1976; Ofen et al., 2012). Thomas (1980) reported that one potential reason for differences in motor performance and learning between children and adults could be due to developmental differences in motor memory. Chi (1976) also proposed that handling information becomes more effective as children mature. Motor memory is “the persistence of the acquired capability for performance” (Schmidt et al., 2018). Research has shown that children differ from adults in the functions of the memory system. For example, Ofen et al. (2012) found neurophysiological evidence that supports developmental increase from childhood to adulthood in memory-related activations in certain areas of the brain related to memory retrieval. Memory retrieval is shown to be important for memory encoding which ultimately helps improvement in motor performance and learning (Ofen et al., 2012). Children are more limited than adults in the ability to handle increased information loads than adults (Thomas, 1980). Therefore, differences

in motor memory development could also be one of the reasons for differences between motor performances of children versus adults.

More importantly, adult gymnasts had relatively higher years of experience in gymnastics than children gymnasts. Research has shown that developing skilled performance at experts' level requires more than a decade of experience which comes from a sufficient amount of structured practice with effort and concentration (Ericsson et al., 2006). The adult gymnasts who participated in this study had about 7 years more experience in having structured practice than children gymnasts. Therefore, it is possible that the performance of adult gymnasts with higher levels of expertise and practice experience was better than children gymnasts with lower levels of expertise and practice experience.

*Practical application*

From a practical standpoint, the results of the current study provide important information for coaches and teachers who are dealing with enhancing performance in form-based elements. For example, it seems to be challenging for coaches in gymnastics, diving, or synchronized swimming to find suitable external focus instructions for improving form-based elements. Due to the nature of these motor skills, instructors frequently provide instructions that encourage the internal focus of attention that directs performer's attention to their body movements. The findings of the current study showed that using simple external cues on the body (e.g., a tape) could promote an external focus of attention and resulted in immediate improvement in performance outcomes. The current findings provide an alternative method for coaches and trainers who teach motor tasks that do not involve an implement (Porter et al., 2010) and require movement form. Therefore, for correcting movement patterns and improving techniques in ballet or synchronized swimming, a set of external

focus cues, metaphors or images may be an efficient way to improve overall performance (Abdollahipour et al., 2015; Guss-West & Wulf, 2016).

*Limitations and future directions*

Although the findings of the current study support the advantages of an external over the internal focus of attention in a form-based motor task in both children and adults, the small sample size may limit the generalization of the findings. Even though there were a limited number of participants in the current study, the effectiveness of external relative to internal focus instructions was observed. Yet, we suggest that the influence of attentional focus instructions on form-based motor skills with a larger sample size should be considered in future studies.

Although our findings showed immediate benefits of an external relative to internal focus instruction on motor performance, it would be interesting to examine the effectiveness of attentional focus instructions on form-based motor skills in long-term motor learning tests (e.g., retention and transfer). Although rehearsal instruments aren't required to be present later, during competitions, it would be worthwhile to examine if the benefits associated with promoting external focus of attention using an external cue, are still validly when the external cue is removed during retention or transfer tests.

## 3.2. Conclusion

The results of the current study showed that the external relative to internal focus instructions enhanced motor performance of a persistent movement form-based element, in both children and adults. That is, with having fewer execution faults, external focus instructions promoted the motor performance of a gymnastics element (i.e., L-support), that requires high precision and persistent hold. Moreover, adults performed the form-based element better than children, regardless of the

attentional focus instructions. Overall, within the framework of attentional focus literature, the findings of this study support the notion that beneficial effects of an external relative to internal focus instruction on motor performance could be expanded to motor tasks that require persistent movement form, regardless of age group.

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