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The Effect of Controlled Movement Imaginary on Performance in a Modified 7-Metre Shot Test of Elite Female Handball Players

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ABSTRACT

Movement imagery may have a favourable influence on subsequent movement performance. As a result of creating a multi-modal movement image in the mind, there are activated specific brain centres that are identical for both movement planning and actual movement action. The objective of this experiment was to find out whether a single ideomotor intervention can influence the accurate execution of a known movement skill. The research sample consisted of adult female handball players who participate in the highest Czech handball competition. The selection was intentional to ensure the homogeneity of the sample in the level of mastery of the tested handball movement skill, namely shooting/throwing from 7 meters. A modified test was used, which was unknown to the probands. The research sample was randomly split into experimental and control groups. Testing included a pretest and a posttest. It was repeated twice over the period of 2 months. The non-parametric Mann-Whitney U test was used to statistically evaluate the data and substantive significance was assessed using Hedges' g. Players assigned to the experimental group performed significantly better in the posttest on both measures of the modified test (1st measure p=0.03, g=1.14, 2nd measure p=0.01, g=1.33). It has been found that a one-time ideomotor imagery intervention can affect the accuracy of a modified 7-metre shot test.

Keywords: movement imagination; handball; 7-metre shot

INTRODUCTION

Movement imagery (MI) can be defined as the process of creating self-images in the movement in our mind without performing the resulting movement action (Emerson et al., 2018). Generally, the creation of images in our mind is called mental representation. To generate images, visual

and kinaesthetic systems are most used (Guillot & Collet, 2010; Krüger et al., 2020). However, the degree to which the mental representation of movement will be most accurate, and which sensory modalities will be particularly represented, depends on our prior experience with a particular movement skill or similar movement skills (Smith & Holmes, 2004). MI is conceived as a cognitive process that allows to represent perceptual information in the mind without sensory input, and with no real motor output (Mulder, 2007; Munzert et al., 2009). Recently, a number of new approaches to the question of mental representation of movement have emerged, building on the ideas of Herbart (1825) and James (1890), who laid the foundations of ideomotor theory. Initially, these theories were criticised as they did not provide a clear mechanism to explain how movement performance is modified by imagery (Murphy, Nordin, Cumming, 2008). The development of imaging methods has advanced the investigation of the brain and processes taking place in the central nervous system (CNS) in such a way that confirmed the earlier assumption of so-called functional equivalence (Murphy et al., 2008). This means that the mental representation of movement requires the activation of brain regions which participate in the preparation and execution of a particular movement, while inhibiting the actual movement expression (Lotze & Cohen, 2006; Murphy, 2008). Movement representations are similar to movement planning to the extent that the process is initiated by representations of relatively remote results, and then gradually supplemented with details (Rosenbaum, 2021). Simultaneous electroencephalograph (EEG) measurements have provided evidence that motor representations may be influenced by the particular result to which they are aimed, and on the similarity or dissimilarity of the target (Ménoret et al., 2014). Therefore, it is possible to work with the idea that movement actions tend to produce results based on motor representations, which always precede the planning of movement. (Sinigaglia & Butterfill, 2022). A systematic review highlights the fact that controlled elicitation of mental representations improves performance in motor tasks, in competitive situations, and facilitates motor learning (Simonsmeier et al., 2021). In fact, in any preparation for motor performance, mental imagery is part of a mental routine, which may include inner speech, muscle relaxation, mental relaxation, and focus on achieving a set goal (Dickstein & Deutsch, 2007).

Handball is considered a contact sport goal game of the invasive type. The course of the game at the highest level is very dynamic. The physical demand of handball is confirmed by a few studies (Garcia-Sanchez et al., 2023; Karger & Buchheit, 2014; Wagner et al, 2014). Apart from the very high physical load, players continuously receive many stimuli to which they must react as quickly as possible. In matches, high demands are particularly placed on cognitive functions – the level of quality and speed of sensory perception, thinking, attention, and control of emotions. During training, emphasis is placed on fitness preparation, especially on the development of speed and strength skills, practising the technique of game skills and their use in game combinations and game schemes. This is somewhat in contrast to the objective of the competition, in which the focus is on precision execution of movement skills under stress conditions in a dynamically changing game environment. Metacognitive skills also involve self-regulatory processes such as control and regulation of athlete's performance of movement demands and goals (MacIntyre et al., 2014).

The effect of ideomotor training, where the controlled creation of mental representations of movement repeatedly occurs, has been shown many times (Callow et al., 2001; Velentzas et

al., 2011). However, this experiment presents only one controlled imaginative intervention. The objective of our investigation was to verify whether a single imagery intervention could affect performance in the accuracy of the 7-metre shot in premier-league female handball players.

METHOD

The research sample consisted of 16 adult female handball players (n=16) who regularly participate in the Czech Republic's premier league women's handball competition at the age of 18–33 (±4.5) years. All the tested persons regularly participate in training and competition activities. Each of the players has been playing handball for at least six years. The research sample was randomly divided into the experimental group (n_e = 8) and the control group (n_k = 8). The players were informed about the substance of the research and signed an informed consent. The experiment took place as part of regular training during the competition period.

Description of the modified test of 7-metre shots of own design

The target, which took the form of a 35 × 35 cm square with an inner hole of 30 × 30 cm, was positioned in the upper left corner of the handball goal. The task of the players was to score a handball from the 7-metre shot mark, from a stationary position, into the target so that the ball passed through the target into the goal. The shots were executed with a women's handball, having a circumference of 54–56 cm. The test always included 10 shots. The control group completed a pretest, a five-minute break, followed by a posttest. The experimental group completed the pretest, and, during the break, the tested persons listened to the intervention, which lasted 4 minutes and 17 seconds. This was followed by the posttest. The modified test was performed by the players for the first time at the pretest of the first measurement. They had never practiced shooting 7-meter shots in this way before. The test was performed under training conditions.

Figure 1. Illustrative photo of the conditions of the modified 7-metre shot test (source: own).

Description of the intervention measure-controlled motor imagery

The intervention measure represented a recording which included a relaxation part and an imagery part. While lying on their backs, the players used headphones and listened to the intervention. In the relaxation part, the tested persons were provided a suggestion to calm down, and to concentrate on themselves. In the imagery part, the suggestion was provided, in which the players imagined hitting the target in the goal very accurately, and successfully performing the given movement task. The arm movement was fluent, sufficiently fast, and precise to hit the target accurately. Then, the players stood up, mobilised at their own discretion, and performed the posttest. To increase the conclusiveness of this experiment, the test was repeated with the same research sample two times consecutively over the period of 2 months.

For statistical processing, the modus and median values were used as measures of central tendency, and the non-parametric Mann-Whitney U test was used to compare intergroup differences. The significance level α was set at 0.05 ($\alpha \leq 0.05$) The substantive significance for our testing was determined using Hedges' g.

Environment for testing and conditions of measurement

The testing was conducted repeatedly in the same area, this means in the hall where the handball team routinely trains. The ideomotor intervention was also in the standard form of a recording used for all probands of the experimental group.

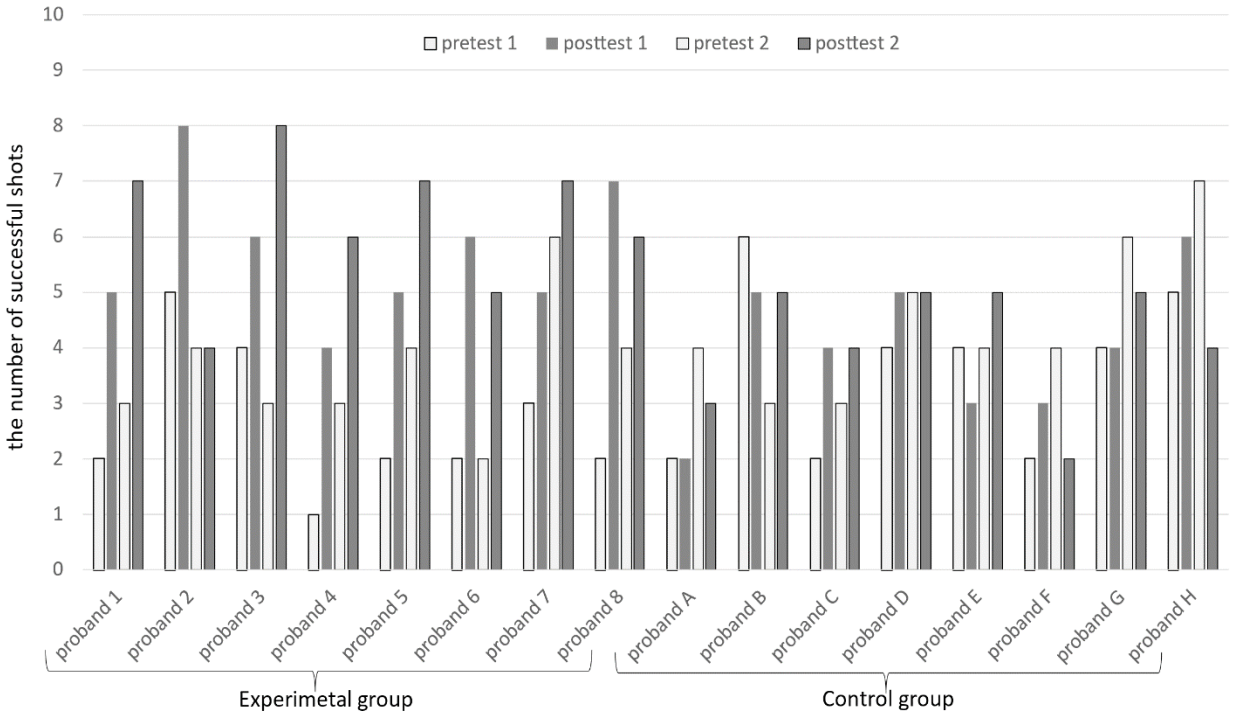
Description of the variables

- **Pretest 1:** scores of the initial testing of 7-metre target shots in the first testing period
- **Posttest 1:** scores of the final testing of 7-metre target shots in the first testing period
- **Pretest 2:** scores of the initial testing of 7-metre target shots in the second testing period
- **Posttest 2:** scores of the final testing of 7-metre target shots in the second testing period
- **Difference 1:** difference noted between the pretest and posttest scores in the first testing period
- **Difference 2:** difference noted between the pretest and posttest scores in the second testing period

RESULTS

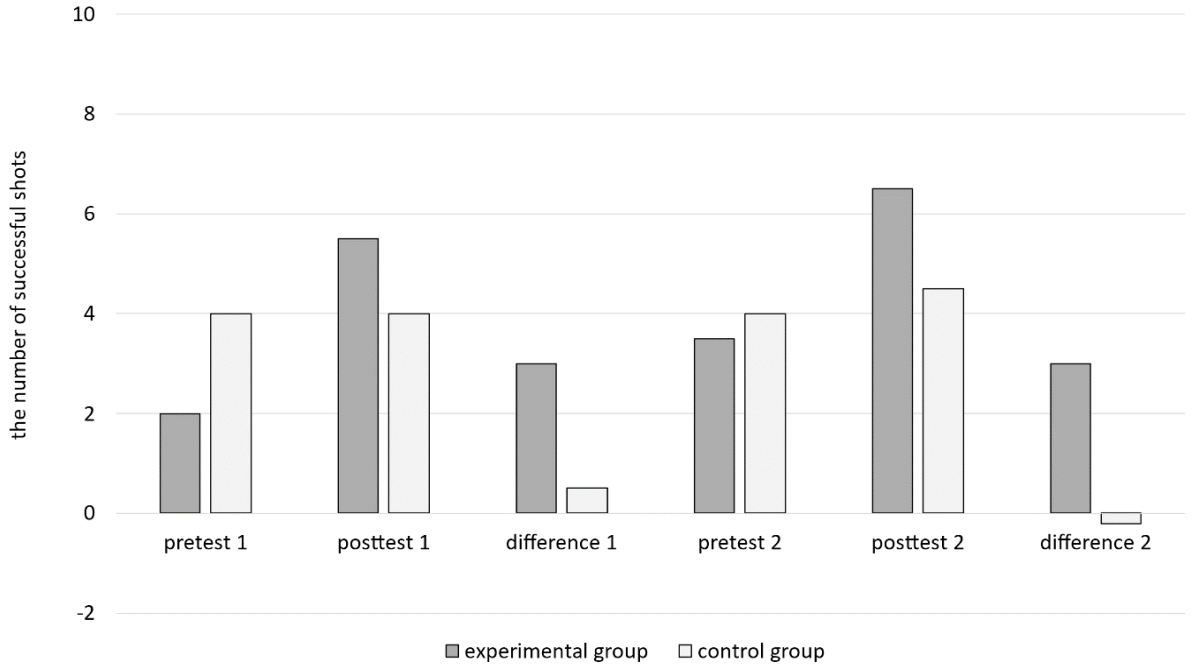
In both measurements, performances of the players in the experimental group were worse than performances of the players in the control group. This phenomenon appeared randomly, and the intergroup differences in the pretest were not significant. After application of the ideomotor intervention, all players in the experimental group showed an improvement in the first measurement by at least two successful shots, and a maximum of five successful shots (Graph 1). In the second measurement, the performance of one player in the experimental group stagnated, and she reached the same performance as in the pretest. In the control group, two players worsened their performance in the posttest of the first measurement, two players stagnated in their performance, one player improved by two successful shots, and three players improved by one successful shot. In the second measurement in the control group, even four players worsened. One player from this group had seven successful shots in the pretest of the second measurement, but only four successful

shots in the posttest. In Graph 1, you can notice the fact that the absolute highest number of successful shots was achieved by two players of the experimental group in the posttest. The largest difference between the pretest and posttest can be seen in the players of the experimental group, e.g. the player marked Proband 3 showed an improvement of five successful shots between the pretest and posttest in the second measurement. The same large improvement is also seen in the first measurement for the player marked Proband 8. In the control group, some players also showed an improvement between the pretest and posttest. In each measurement, there was one player who increased the number of successful shots in the posttest by two shots (Proband C and Proband B). In the control group, half of the players in the group worsened or stagnated in performance at each measurement.



Graph 1. Graphical representation of the number of successful shots achieved in the modified 7-metre shot test by the whole research sample in the pretest and posttest for both measurements.

When comparing the median values of the control and experimental groups, it is evident that the control group achieved a higher score of successful attempts in the 7-meter bullet test in the pre-test of the first and second measurements. In the posttest, the opposite is true (see Graph 2). The extent of the differences between the pretest and posttest scores in both measurements also indicates the impact of the single ideomotor intervention on performance in the modified 7-metre shot test.



Graph 2. Comparison of the median scores of the experimental group and the control group in the pretest, posttest, and the difference variable between the pretest and posttest from the first and second testing.

Table 1. Statistical evaluation of the differences in performances between the experimental group and the control group in the Mann-Whitney U test, and practical (substantive) evaluation by Hedges' g.

	U	Z	p-level	Hedges' g
Pretest 1	20	-1.26	0.21	0.69**
Posttest 1	11	2.2	**0.03***	**1.14*****
Pretest 2	20	-1.26	0.21	0.65**
Posttest 2	7	2.62	**0.01***	**1.33*****

$p \leq \alpha \leq 0.05$, * the difference is significant, ** the difference has medium substantive significance, *** the difference has strong substantive significance

By statistical evaluation of the collected data, it is apparent that there are no statistically significant differences between the experimental group and the control group in the pretest. In the posttest, there is a significant intergroup difference for both measurements (see Table 1).

The values of substantive significance highlight the medium significance of the differences between the groups for the pretests of both measurements. From the Graph 2, the players of the control group entered the testing with better scores in the modified 7-metre shot test than the players of the experimental group. After intervention mediating the mental representation of a successfully performed movement skill, the players of the experimental group achieved a better test score such in such a way that the difference between the groups is statistically significant, and substantive significance is strong.

DISCUSSION

The objective of our investigation was to verify whether a one-time imagery intervention could affect performance in the accuracy of the 7-metre shot in premier-league female handball players. The experimental results suggest the possibility that a single ideomotor intervention may affect the accuracy of the 7-meter throw, which was confirmed for both measurements. Statistical comparison of the performance of the experimental and control groups in both measurements shows statistical significance (p=0.03 and p=0.01, respectively). Also, substantive significance indicates a high effect size (g=1.14 and g=1.33, respectively).

A close relation to our topic is found in research that assesses the training of a two-step rhythm ending with a basketball shot (two-stroke). This research shows that the subjects, who practised both imagery training and movement training over a period of four weeks, achieved a significant improvement in the quality of movement skill performance compared to the subjects who performed only physical training (Gaggioli et al., 2013). Mental representations of movement are also used to control emotions during movement action (Ramsey & Cumming, 2010), or to increase self-esteem and self-confidence (Callow et al., 2001).

It was confirmed that elite players (basketball, soccer, badminton, handball, and volleyball) have higher scores of internal visual and kinaesthetic images in the questionnaire survey than low-performing players and non-athletes (Nezam et al., 2014). In our experiment, the different inter-individual ability of movement imagination was addressed. The players completed the Vividness of Movement Imagery Questionnaire (VMIQ-2), which is standardised in the Czech language (Kavková & Vičar, 2014). This was only a supplementary investigation to eliminate the possibility of having a player in our research sample who was significantly limited in her motor imagery ability. None of the players from our research sample reached the critical values specified in the VMIQ-2 questionnaire manual (Kavková & Vičar, 2014), which means that all the tested persons had adequate motor imagery ability. When comparing the raw scores of points collected in the questionnaire survey, and the raw scores of successful shots in the modified 7-metre shot test, there was no correlation between these values.

Naturally, the idea is suggested whether some of the players assigned to the control group, who performed reasonably well in the pretest (seven and six successful shots), could have further improved performance in the posttest. This phenomenon was evident mainly in the first measurement. In the second measurement, the absolute difference between the groups was not so great, even though the sum of the rankings in the Mann-Whitney test was similar. There is statistical and substantive confirmation of the positive change in the number of successful shots among the players who underwent the single controlled ideomotor intervention.

The players were not subjected to any mental pressure related to the match and its development. The success rate of 7-metre shots in our test may not correlate with the success rate of goals scored during 7-metre shots in a competition where the goalkeeper and other factors play their role. In general, the performance of handball male and female players is influenced by many factors. The research results on the effectiveness of movement imagery show that there is its essential effect in the process of practising, or, if you wish, training of new movement skills. The creation of

mental imagery, however, cannot substitute the practical part of training, but it can appropriately complement it. It can be assumed that if the experiment described here were repeated with similarly advanced handball players, similar results would be achieved.

CONCLUSION

The effectiveness of long-term ideomotor training in the form of movement imagery on the real movement performance of an individual has been demonstrated in many studies over a great number of years. It was able to demonstrate that a single imagery intervention also significantly affects the accuracy of movement performance. There is a good reason to believe that the correct imagery of the movement skill, concentrated, goal-directed planning, and imagining the performance of a successful movement action, will have an impact on activation of the nervous system, self-esteem, and self-confidence.

The concept of movement imagination is used in practice especially in movement performances, the variability of which is not too high during the performance. We are of the opinion that it is appropriate to include image exercises in the training and training of many other sports performances at all levels, including games. This article presents evidence of the meaningfulness of one-time guided imagery on the actual execution and accuracy of the practiced movement skill. It would be very interesting to test positive imagery in a match situation.

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