RBCDH Revista Brasileira de CINEANTROPOMETRIA e Desempenho Humano

DOI: http://dx.doi.org/10.5007/1980-0037.2014v16n1p47

original article

Acute effect of motor imagery on basketball players' free throw performance and self-efficacy

Efeito agudo da imagética no desempenho de lances livres e percepção de autoeficácia em atletas

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Abstract – It is becoming ever more common for the difference between winning and losing in sport to be decided by the smallest details. In basketball, free throws can be a differentiating factor between teams and motor imagery (IMA) has been studied as a potential ergogenic agent to improve free throw performance, but little attention as been given to its acute effects, particularly among athletes. The objective of this study was to investigate the effect of a single mental training session on the free throw performance and self-efficacy of young athletes. Eleven young basketball players from the Federação Paulista de Basquete junior league were enrolled on the study. Players were either allocated to an IMA group and watched a 1 minute video before a 3-minute motor imagery session, or to a control group and were rested for 4 minutes, before taking 10 free throw shots in both cases. All participants completed a self-efficacy questionnaire before and after the intervention. Statistical analysis was conducted using the Mann-Whitney U test and the Wilcoxon test, plus measures of Smallest Worthwhile Change (SWC). There were no significant difference between median results for the two groups, but the SWC statistic indicated an 84% likelihood that mental training had a beneficial effect on performance in the first two free throws. It is concluded that motor imagery used in advance has an 84% chance of having a beneficial effect on performance in up to two free throws.

Key words: Self-efficacy; Athletic performance; Applied psychology.

Resumo – *O esporte cada vez mais diferencia vencedores e perdedores por mínimos detalhes. No basquetebol um fator diferenciador é o lance livre. Sessões de imagética motora (IMA) vêm sendo estudada como um ergogênico sobre o desempenho de lance livre, porém, pouco se estuda o seu efeito agudo, principalmente, em atletas. O objetivo desse estudo foi verificar o efeito de uma sessão prévia de treinamento mental sobre o desempenho no lance livre e na percepção de autoeficácia de jovens atletas. Participaram do estudo 11 atletas juvenis da Federação Paulista de Basquete. Na condição IMA, foram submetidos a 1 minuto de vídeo + 3 minutos de imagética, seguidos de 10 lances livres, e no controle, 4 minutos de repouso seguidos de 10 lances livres. O questionário de autoeficácia foi preenchido antes e após a intervenção. Para análise estatística, foram utilizados os testes U de Mann-Withney, Wilcoxon e o Smallest Wothwhille Change (SWC). Não foi encontrada diferença entre a mediana dos grupos, porém, o SWC apontou uma possibilidade de 84% de efeito benéfico do treinamento mental sobre o desempenho para até 2 lances livres. Concluiu-se que a imagética motora prévia tem 84% de chance de causar um efeito benéfico sobre o desempenho de lance livre em até 2 arremessos.*

Palavras-chave: *Autoeficácia; Desempenho atlético; Psicologia aplicada.*

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Received: 21 January 2013
Accepted: 23 July 2013

INTRODUCTION

Motor imagery can be described as a dynamic mental effort in which a movement is visualized and created mentally, but which involves no physical movement of any part of the body that would be used to perform the task being imagined[1]. In general, motor imagery has been shown to be beneficial to athletes when added to their normal training and this effect appears to be linked with the number of sessions; i.e. it offers benefit over the long term[2-4]. In contrast, the evidence for acute effects is inconsistent. Lamirand and Rainey[5], for example, have questioned the existence of an acute effect, since a study they conducted with basketball players showed that relaxation training was effective, whereas motor imagery exhibited no effect on free throw performance. However, their study design only allowed them to speculate that imagery probably did not have any short-term effects.

Certain factors are considered of fundamental importance if motor imagery training is to achieve the positive results that are hoped for. These include individual training sessions, training with the eyes closed, training motor tasks, the type of instructions given and the type of population trained[4]. Lafleur et al.[6] have suggested that motor imagery should address the motor action actually demanded by the sport the athlete competes in, in order to cause the same cerebral plasticity that is provoked by physical training and to recover the cognition employed in specific tasks, or to improve their performance by means of mental practice[3,7-10]. It should also be pointed out that successful motor imagery is dependent on a good capacity to visualize oneself performing a task effectively; in other words, it is dependent on good self-efficacy[11].

The rules and playing conditions of many team sports, including basketball, provide for certain critical moments that are not infrequently responsible for deciding which teams win and lose a match and which can be modulated using motor imagery, possibly leading to improved performance.

Basketball demands mastery of several distinct skills, including the abilities to dribble, pass, crossover, block and rebound and to score baskets from lay-ups, jump shots and free-throw shots[12]. Free-throw shots have received greater attention than any of the other basketball skills and studies have focused on aspects ranging from variability in the mechanics of throwing at different skill levels[13], to the influence free-throws have on the final results of games[14-16], or, more specifically, on the results of close games in which there is little difference between the two teams' final scores[14].

Free throws are not only important because they offer a chance of scoring a basket, with no chance that the ball will be intercepted by an opposition player, but also because the free throw action is known in advance and can therefore be practiced. The free throw line is a standard distance from the hood, which in turn is of a standard diameter and fixed at a standard height, in other words, since players know that there is always the possibility of free throws during a game, they can train the action and perfect it. Finally, scoring a free-throw basket denies the opposition team the chance of a defensive rebound which is of fundamental importance to a precise and rapid counter-attack, showing that the absolute number of free throws from which baskets are scored is not the only important factor, since the proportion of free-throws scored is also significant[14].

It is therefore clear that factors that can impact on free throw performance, whether positively or negatively, need to be taken into consideration. Along these lines, studies have been undertaken to determine whether motor imagery sessions over an extended period can improve free-throw technique[5,17,18]. However, there do not appear to be reports in literature dealing with a possible acute effect from the use of motor imagery, more specifically on free-throw performance. In view of this, the objective of this study was to compare the acute effect of a single motor imagery session on the free-throw performance of young basketball players.

METHODOLOGICAL PROCEDURES

The study participants were 11 young basketball players with a mean age of 17.6 $\pm$ 0.5 years, mean time playing of 5.9 $\pm$ 1.7 years, mean height of 1.88 $\pm$ 8 meters and mean body mass of 75.9 $\pm$ 8.6 kg. They were all from a single team in the youth league of the Federação Paulista de Basquetebol, which is the strongest championship in Brazil. Additionally, two of the players had been among the previous season's top scorers and all had competed in championships at state level or higher in previous years. Finally, at the time the study was conducted, their team had 3rd place in the São Paulo state youth games basketball category and was basketball champion of their region's youth games. None of the participants had previous experience of mental training.

All participants were informed of the research objectives and the procedures involved and signed a free and informed consent form that contained explanations of the objectives and risks of the study and assurances that all participants were free to drop out of the study at any point they wished to do so. Minors were also asked to provide signed consent from their guardians on an identical form. The study was approved by the Human Research Ethics Committee at the Universidade Estadual de Maringá, under protocol number 339/2011.

Data collection procedures

The participants were initially divided at random into two groups, a control group (CON) and a motor imagery group (IMA), which were reversed on the second day of testing to provide crossover data. All tests were conducted at the start of the team's training sessions, which was the time that the team's coach had allocated for the study. Each participant was prepared and tested separately. First the participant was taken to a room off the basketball court, less than 20 m from the basket where the tests would be conducted. They were then asked to respond to a General Perceived

Self-Efficacy Scale (GPSES) questionnaire[19] to provide a baseline of each participant's capacity to imagine themselves successfully performing the task. [11] The concept of self-efficacy is not new to sports science[20], and the questionnaire itself has been used previously[21]. Once they had completed the questionnaire, each participant went either to the IMA or the CON session and after both sessions had finished each participant completed the questionnaire once more. They were not informed in advance that they would complete the questionnaire twice, to avoid any attempt at memorizing the answers. Once finished, participants were immediately sent to the court for the performance test.

Motor imagery session (IMA)

Once they had completed the GPSES for the first time, the participants in the IMA group were instructed to watch a video of great players from the NBA scoring free-throw baskets in order to help provide them with images of successful free throws, so that even those who were less skilful at free throws themselves would be able to imagine them as effectively as possible[22]. It should be pointed out that this procedure is in accordance with Bandura's theory that the objective is to achieve an ideal comparison. After the 1 minute video had finished, participants were given the following motor imagery instructions: sitting down, with eyes closed, try to imagine the entire throw, from the movements of the body with a mechanical image of the arm and the trajectory of the ball through the air, emphasizing the ball being released and entering the hoop. The imagery training lasted 3 minutes and was timed and supervised in silence by a researcher. All instructions were given to the participants by the same researcher.

After the 3-minute motor imagery session was over, the participants were asked to complete the GPSES again as truthfully as possible and without concerning themselves with their replies the first time it was administered. They were then sent to the basketball court to do the free throw performance test.

The participants were asked three questions for qualitative quality control of their imagination levels soon after the performance test, as follows: Were you imagining in color or in black and white? Was there sound? Were you imagining from the first or third person perspective?

The CON group were asked to respond to the GPSES questionnaire and then taken to another room for 4 minutes, timed, and were then asked to answer the GPSES questionnaire again before being taken to do the free throw performance test. The participants who attended the IMA session on the first day were asked not to talk about the session until the other group had done the IMA too.

Performance Test

The performance test was conducted using a Penalty 7.4 ball and a hood height of 3.05 meters. The participants from both groups were given the same instructions: to take 10 free throw shots and try to do as well as possible in all of them. The researcher was responsible for passing the ball to the participant before each throw and for collecting rebounds and netted shots, so that the player did not have to leave the free-throw line. The researcher passed the ball with a single bounce, as is done by the umpires during a game, aiming to reach the player at chest height. Between shots, no type of feedback whatsoever was allowed, whether from other players or the researcher.

Data analysis

The performance data were tested for normality and, since the majority were not normally distributed, nonparametric statistics were adopted. The CON and IMA groups' performance test results were analyzed using the man Mann-Whitney U test for unpaired comparisons and the Wilcoxon test was used to compare the 2 days' results. Since the GPSES questionnaire data did exhibit normal distribution, they were analyzed using the *t* test for paired observations or the unpaired *t* test for comparisons across groups. All analyses were conducted using PASW 18.0 statistical software with the significance cut-off set at 5%.

In view of the factual context of the study, descriptive, qualitative and percentage analyses were conducted in parallel. Additionally, the smallest worthwhile change (SWC) methodology was adopted. The SWC approach is often used in sporting contexts to help identify ergogenic agents, by estimating the probability of an effect being a worthwhile improvement, a substantial impairment, or a trivial change in performance. Its main application is for sports in which minimal differences in performance are very hard to achieve, but have an enormous potential to affect results. The percentage likelihood that the effect on performance was beneficial/trivial/harmful was quantitatively and qualitatively evaluated using the following classification categories: < 1% most unlikely, almost certainly not; 1%-5% very unlikely; 5%-25% unlikely, probably not; 25%-75% possibly; 75%-95% likely, probably; 95%-99% very likely; >99% most likely, almost certainly[23]. Each figure is calculated separately, taking into account likelihood, confidence interval, degrees of freedom and variance of means. Spreadsheets for using these categories are available at http://www.sportsci.org/resource/stats/index.html. If both the likelihood of a beneficial difference and the likelihood of harmful difference are estimated to be greater than 5%, then the effect is defined as "unclear"[23].

The participants' imagination levels were graded on the basis of their answers to the questions they had been asked after the IMA session, on a scale ranging from 0 to 3, where the closest approximation to reality scored highest.

RESULTS

Table 1 lists the results of the qualitative analysis of participants level of imagery during the experimental protocol. Participants scored one point each for imagining in color, with sound and from their own (first person) perspective, because all these elements are present when executing the task in reality.

Table 1. Individual and mean imagination levels during motor imagery session. Color = 1 point; sound = 1 point; first person perspective = 1 point.

Participant	Color	Sound	Perspective	Score
1	Yes	No	3ª	1
2	No	No	3ª	0
3	Yes	Yes	1ª	3
4	No	Yes	3ª	1
5	Yes	No	1ª	2
6	Yes	No	3ª	1
7	No	No	1ª	1
8	No	Yes	1ª	2
9	No	No	1ª	1
10	No	Yes	3ª	1
11	Yes	No	3ª	1
Total	5	4	5	1.27

Figure 1 illustrates the results for absolute free throw performance in four categories (after 2, 3, 5 and 10 shots), shown as medians and interquartile ranges, comparing the two experimental groups (control vs. motor imagery). No statistically significant differences were observed (p>0.05).

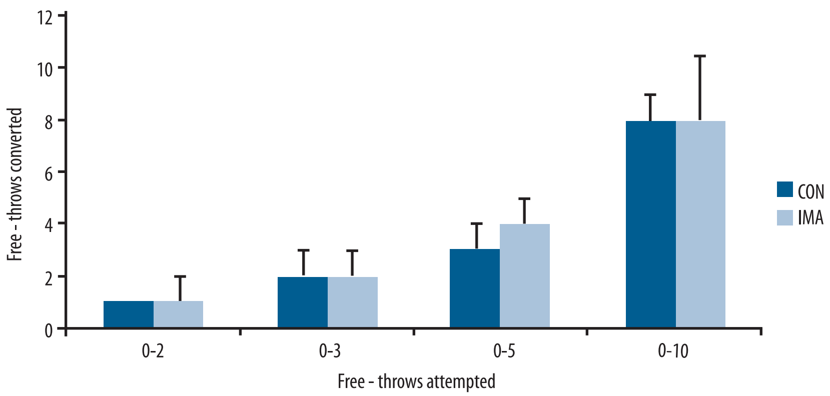

Figure 1. Difference in free throws made, shown as medians and interquartile ranges, comparing the two experimental groups, control vs. motor imagery, (p>0.05, n = 11).

The results from the GPSES questionnaire are illustrated in Figure 2, comparing before and after (Pre and Post) the session for both groups (IMA or CON). Comparisons found no significant differences, whether for before versus after or for control versus intervention (p>0.05). The figures used were as follows: CONpre = 32.2±3.1. CONpost = 32.8±2.9. IMApre = 31.8±2.1. IMApost = 32±2.3. CONpre X CONpost (t = 0.392; p = 0.237). IMApre X IMApost (t = -0.539; p = 0.602); CONpre X IMApre (t = 0.392; p = 0.699); CONpost X IMApost (t = 0.630; p = 0.536).

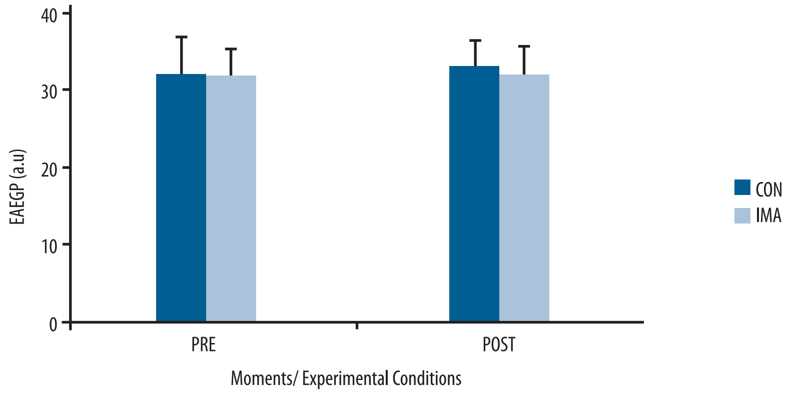

Figure 2. Comparison of GPSES self-efficacy results. Values are expressed in arbitrary units (a.u) and shown as means and standard deviations for two experimental groups, control and motor imagery, and before and after the session, pre and post, (p>0.05, n = 11).

Figure 3 illustrates the percentage of successful free throws made in each group after 2, 3, 5 and 10 shots. There is a visually detectable difference up to 2 shots, which is confirmed by the results shown in Figure 4. The motor imagery technique's effect can be seen to reduce as more shots are taken. Figure 3 was analyzed qualitatively.

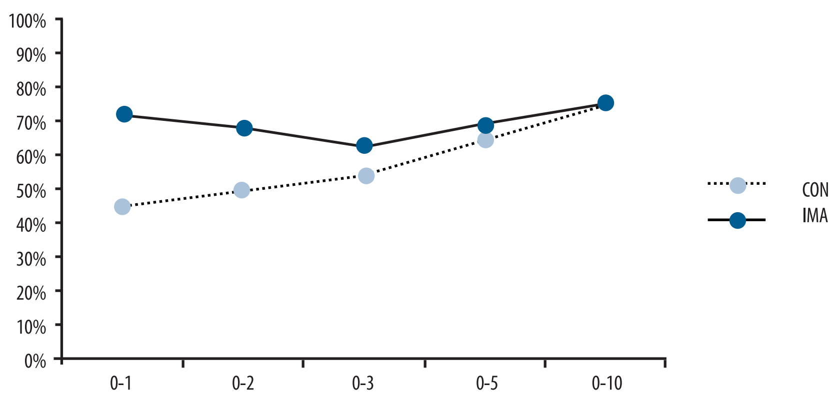

Figure 3. Percentage of free shots made in each group (control and motor imagery) after 2, 3, 5 and 10 shots.

Figure 4 illustrates the SWC for motor imagery vs. control after 2 free throws. There was an 84% likelihood that the IMA intervention would have a beneficial effect, which is defined as "likely, probably" according to the classification adopted. None of the results for greater numbers of free throws achieved non-triviality.

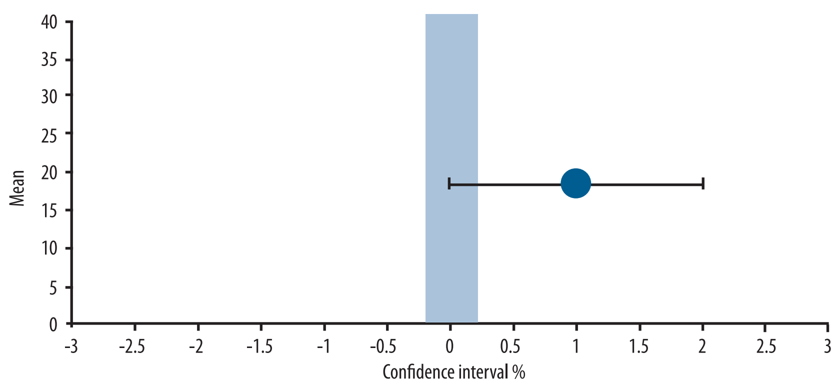

Figure 4. Smallest worthwhile change for Control against Motor Imagery groups (84/12/4) after first two free throws. Note: means and confidence intervals are derived from percentage differences normalized by the standard deviation.

DISCUSSION

The short term effect (on the first two free throws) of the motor imagery technique indicated by the results of this study is plausible, since continuing the activity appears to reduce the acute effect of the strategy, to the extent that the activity engaged in becomes the most important element, making the ergogenic agent ineffective over the medium and long term. Adoption of a progressive statistical analysis capable of detecting smallest relevant effects showed that using motor imagery prior to shooting free throws offers the possibility of a beneficial effect on players' performance. Although this effect was of short duration and low magnitude, it could still be of great importance because it is possible for a team to be awarded two free throws, indeed it is one of the most common occurrences in basketball matches and is responsible for the great majority of teams' points during the final minutes of closely balanced matches[14]. This is primarily because the team that is behind in points will commit fouls on purpose, giving away free throws and stopping the clock in the hope that the physical demands of the game will make the player miss. However, when it is absolutely essential to make the free throw, a time out can be called, giving the player who is going to take the free-throw shots time to engage briefly in motor imagery, possibly increasing the chances of success. However, this study's design makes it possible to raise this hypothesis, but not to confirm it sufficiently to be able to recommend the technique. To provide this degree of certainty a more ecological study design would be needed, similar to the one conducted by Seif-Barghi et al.,[24] in which football players' passing performance was analyzed during matches.

Closer inspection of Figure 3 reveals that when the participants engaged in motor imagery training the achieved constant rates of successful free throws, but also shows that when they were assigned to the control group, their final scores were not inferior to their scores in the IMA group. It is the authors' opinion that the fact that players had missed shots early on made them concentrate more on subsequent shots in order to make what they considered to be the minimum number of successful free throws, compensating for the earlier errors, whereas those in the IMA group maintained a constant rate of success, because they were already scoring at a rate they considered acceptable for 10 shots.

This study's results are in agreement with the findings of published literature showing that motor imagery can be used as a psychological ergogenic technique, possibly as a result of neuromotor or psychosomatic changes[2,3,24-26]. However, in the present study motor imagery was used in an acute manner, i.e., the effect was tested immediately after a single session, in contrast with the other studies in the literature, in which the effects of chronic motor imagery training were investigated. [3,24-27] Notwithstanding, it is worth remembering that analyzing performance in terms of percentages has true ecological validity when studying basketball, since results are summarized this way over the course of training and competitions, for evaluating both individual players' and whole teams' performance, both by coaches and championship organizers.

The results of the GPSES questionnaire indicated that the players had high levels of self-efficacy (>30 a.u) irrespective of their imagination level, day-to-day situation or emotional variations, which is to be expected since the participants were both adolescents and successful athletes. However, this is not necessarily a controllable variable that affects performance or is capable of explaining results and the motor imagery sessions were ineffective at changing the self-efficacy results, as had been expected a priori, since both the ideal of realization and the intrinsic perception of realization are determinants of the outcome of the task[14]. Furthermore, the questionnaire used measures more than just self-efficacy in the free-throw action and the results of future studies would be enhanced by the development of questionnaires specific to given sports or even to individual skills.

There are certain elements of this study that could be considered limitations, such as the lack of uniformity in the participants' imagination levels, with great variation in players' imagery, in terms of color, sound and perspective. This could mean that the single IMA group was actually made up of heterogenous subsets, although one recent study has shown that the perspective adopted does not appear to make any difference to motor imagery results[29] In other words, in the present study each participant was given instructions and performed motor imagery in their own way, so they were controlled, but not manipulated, as was the case in a study by Guillot et al.[2]. The ideal approach would probably be to subdivide participants on the basis of their imagery levels.

It should be pointed out that these players had never used motor imagery techniques before and we believe that the effects could be even greater if the participants had been trained in using motor imagery, which would increase the benefit that could be achieved in the short time they have available to use the technique during a match. Additionally, the use of a video does not echo the ecological conditions of a basketball match, but this limitation could be eliminated in future studies by incorporating thorough training in the use of the technique, possibly with a kinesthetic approach. Finally, although the sample size is not large (n = 11), these athletes were all trained to the same level, which makes the sample highly uniform.

CONCLUSIONS

In view of the results described here, it is suggested that basketball players should be prepared in advance to use motor imagery, which they could then employ in an acute manner during intervals and tactical time-outs, although the time used must be balanced against time-outs called for the primary purpose of organizing plays and positioning players. Coaches should train their players in the use of color, sound and perspective and it is also recommended that they be trained to perform the technique when near exhaustion, since tiredness can affect the precision of motor imagery[28].

We conclude that a 1 minute video followed by 3 minutes of motor imagery was able to provoke an effect with an 84% likelihood of being beneficial on the first two free throws in a series of 10 young basketball players.

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