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The Effect Ofinitial Practice with Dominant and Non-Dominant Hand on Acquisition, Retention and Transfer of a Complex Motor Task

Malihe Moones Tousi, Toktam Emami and Seyed Mojtaba Hoseini*

Department of Sport Sciences, Ferdowsi University of Mashhad, Iran.

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The purpose of this study is to analyze the effect of practice orderwithdominant and non-dominant hand on acquisition, retention and transfer of basketball dribbling skills of female students at Ferdowsi University. The subjects were 20 female students of General Physical Education (19-24), who did not have any experiences in basketball with dominant right hand. They were randomly selected and equally assigned into two groups. The subjects practiced within the program for 4 weeks, 2 times a week and 45 minutes per session. Group A practiced with their dominant right hand for the first four sessions and then switched to their left hand for the second four sessions. Group B practiced reversely. The subjects were assessed by Slalom-Dribble-Test in pre-test and post-test. Retention and transfer tests were performed one week after the exercise was finished. The results showed that there was no significant difference between the two groups in acquisition of dribbling skill (p=0.053). Movement time has been significantly reduced from pre-test to post-test (p=0.00). The results showed better performance of the right hand compared to the left (p=0.042). Both groups had a shorter dribbling time with the right hand compared to the left hand in the post-test and retention test. There was no significant difference between two groups in transfer task (p = 0.16). The results indicate that practicing with dominant and non-dominant limbs in the initial motor learning seems to be important to improve performance of both limbs and to strengthen bilateral competence of the learners.

Keywords:Inter-manual Transfer, Basketball Dribbling, Skill Acquisition, Retention, Handedness.

Motor learning is defined as a relatively permanent change in behavior, which arises from practice and experience. Assessing progress stability, which is attained through practice, and also evaluation of adaptability of changes in implementation in new occasions are both considered as methods of inference and learning[1-2]. Athletes have to use their skills in sport test, contests and matches. Due to such practical requirements, couches must design and organize training in such a way that leads to greater success in the future occasions. One of the features of exercise that increases the chances of success is variation in leaners' practice experience through a variety of field training and experience. This feature increases one's ability to successfully use his/her individual skills, and it also raises his/her compatibility with new situations. Based on the prediction of Schmidt schema theory, increase in variability within a class of acts promotes skill acquisition[2]. One major goal of exercise is to establish the ability to transfer the skill from exercise environment to other contexts where the

* To whom all correspondence should be addressed.
E-mail: mojtabahoseini_61@yahoo.com

athletes have to use the same skill and achieve the simiar goal[1]. There are distinctive discussions on the transfer of learning by dominant and non-dominant body organ and also on presenting exercises. The results of some studies suggest the symmetry of two-way transfer[1,3]. However, most researchers have concluded that transfer usually occurs asymmetrically for various reasons including the role of different brain hemispheres in controlling the movements, type and complexity of tasks, and the training frequency and performance level of subjects[4-5]. To explain hemispheric cooperation in controlling the movements of both hands to transfer learning, there are 3 models. These models predict the learning transfer direction between dominant and non-dominant hands. According to the callosum (access) model, there is only one motor plan to control both hands, which happens in the dominant hemisphere (left). Dominant right hand has direct access to this motor program while non-dominant left hand only has access via the corpus callosum. Therefore, dominant hand should benefit more from basic motor learning with the non-dominant hand compared to the other direction. However, based on proficiency model(expert), it is assumed that there is a motor plan to control each hand, which is stored in the cross hemispheres (contralateral) by trained hand. In this model, each hand can benefit from the other hand motor learning, and there is no difference in how to start to learn with one hand compared to the other hand. As for cross-activation model, it is assumed that a double motor plan is stored in each hemisphere after the instruction of dominant hand. According to this model, when a dominant hand is under practice, a dominant plan schedule is established in the dominant hemisphere, and less complete plan is designed in the other hemisphere. However, when we start an exercise with a non-dominant hand, only a plan will form in non-dominant hemisphere. Thus, when a non-dominant hand does a task, practiced by a dominant hand, the non-dominant hand gains access to this less complete plan in the non-dominant hemisphere. The model predicts that dominant hand always leads the non-dominant and affects its behavior, yet this does not happen in the opposite direction[6-7]. Recent studies have examined the effects of training with dominant and non-dominant member. In a study on football players, Haaland and Hoff (2003) found that Group of practice with the non-preferred leg performed all tasks (dribbling, volley goal shot, and passing against a mini-goal) better when they were tested after the training period using both legs. Thus, exercise with non-preferred leg led to a better learning of skills in both sides of the body[8].The results of Teixeiraet al (2003) also showed the reduction of lateral asymmetry in soccer dribbling task after training with the non-preferred leg in teenage football players. On the contrary, dominant leg in two other tasks (hitting the ball with power and accuracy) has always maintained his superiority[9]. In a study on the assignment of student football players, Hosseiniet al (2013) showed that transfer of learning in practice assignment of leg side kick (with emphasis on the cognitive component) was symmetric, but regarding leg front kick (with emphasis on motor component of force), transfer of learning was asymmetric and happened from the dominant to the non-dominant leg[10]. In these studies, participants with a dominant or non-dominant limb practiced in a given period before the test, and both sides of the body were evaluated in the post-test. However, the issue that whether there is a certain time point to start practicing with dominant or non-dominant limbs with good impact on the transfer of learning requires more research. In this regard, Senff&Weigelt (2011) studied Sequential effects after practicingwith the dominant and non-dominant hand on the acquisitionof a sliding task in schoolchildren 10 to 12 years and found that the acquisition of task (tossing coins) after initial training was facilitated by non-dominant hand. The findings showed better retention of the task and more precise implementation of group (non-dominant-dominant) compared with the other groups[11]. In a research on the effect of exercise sequence on acquisition of basketball dribbling skills in students 11 to 13 years, Stoeckel et al (2007) showed that the first group (non-dominant-dominant) that did the first half of training sessions with the right dominant hand and the second half with the left non-dominant handhadsignificant retention compared with the other group (the dominant-non-dominant). It is interesting that this advantage was independent of the related hand in the test. Furthermore, a similar pattern of results was found in the transfer test, and shorter transfer time was achieved for non-

dominant-dominant group[12]. In addition, Stoeckel et al. (2007) studied the basketball throwing task in teenagers and foundthat precision in both hands was improved in the group that starter to learn the task with their non-dominant hand. In a study on two groups of teenagers (11-14 years) participating in basketballthrowing task, Stoeckel et al. (2012) found that those who first started with their non-dominant hand in the precision shot exercise had a better skill acquisition. On the contrary, the group which had handball over shoulder throwing exercise (with an emphasis on force) and initially trained with dominant hand took more profits[13]. Such brain lateralization is in line with the dynamic dominance hypothesis of motor control, the general model of hemispheric lateralization and specialized hemisphere/limb system. According to this theory, left hemisphere is primarily responsible for sequentialcontrol of movement patterns (ie, trajectory coordination)and the regulation of movement dynamics while visual-spatial aspects of movement (i.e. control of final position and accuracy of target) are basically processed in the right hemisphere[6, 13]. In sports such as basketball and football, athletes are required to do complex skills not only using their dominant hand or leg, but also with their non-dominant limb. For basketball players to protect the ball against the opponent,they should be able to dribble with both hands, as well as being able to rebound the ball with the non-dominant or dominant hand as it is released from the hoop, depending on ball direction from the hoop and the player's position. Such situations show that use of both sides of body is an undeniable necessity for successful performance in competitive sports.While most coaches and athletes accept the principle, the bilateral acquisition skills are often overlooked in today's training programs. There are uncertainties and challenges regarding effectiveness of various methods of training sequences for learning and lateral transfer, which require further research to illustrateoptimizingmotor learning processes, improving training methods and planning sport skill education.

Thus, according to the results of research conducted on training with the dominant and non-dominant limb and given dynamic dominance hypothesis as well as the general model of hemispheric lateralization and specialized hemisphere/limb system, it seems in learning motor skills with different characteristics, it is of particular importance whether dominant or non-dominant limbs are used at the beginning of practice. This research aims to investigate the effect of the practice sequence with dominant and non-dominant hands on acquisition, retention and transfer of basketball dribbling skills in female students.

METHOD

The research method in this study is quasi-experimental. The population included female students at Ferdowsi University of Mashhad, who had chosen basketball as their physical education course[2] in second semester of 2014-2015. 20 students aged between 19 and 24 years, who had no experience with the experiment task in basketball and other sport activities. They were selected randomly. All participants' dominant hand was their right hand, determined by Stanly Coren'sHand ednessQuestionnaire[14]. The subjects were randomly and equally divided into two groups (A and B).

The research protocol

In this research, Slalom-Dribble-Test was used[14]. The participants were in the standing position behind the starting line. They started their

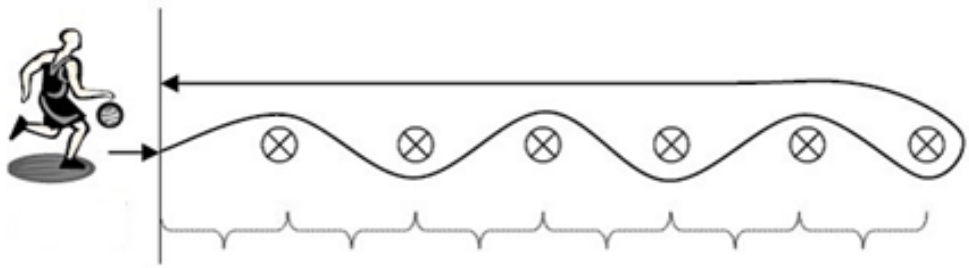

Fig. 1. Slalom-Dribble-Test

dribbles with a "run" command with the highest possible speed and in spiral manner between 6 dribble cones placed in a straight line with 1.5-meter space from each other. After passing the last dribble cone, they were supposed to quickly return to the starting point.

Distance between the starting point and the last dribble cone was 9 meters (Figure 1). The timer was started with a command and stopped after crossing the finish line, thus the test time was recorded. In case during the test, the ball was out of control; it hit a dribble cone, or if a person lost his balance, we repeated the test. In this study, the subjects dribbled once with their right hand and once with a left hand in three stages (pre-test, post-test and retention test). This test was carried out in a standard field of basketball, and a ball with 75 cm in circumference and weighing about 600 grams.Cones with a height of 30 cm were used as dribble cones. A manual stopwatch was used to record the testtime.Slalom-*dribbling* task (SDT) was used in the transfer test. The difference was that in this task, to cross the dribble cones, right and left hands were used sequentially[14]. This shift of hands and crossoverdribble are needed after each cone. Thus, the subjects were taught to dribble around coneusing the external hand. This change was done to simulate the actual playing situation. The researchers were interested to know how the participants were able to use newly learned skills under real game conditions where to protect the ball from a defender, it is important to place the body

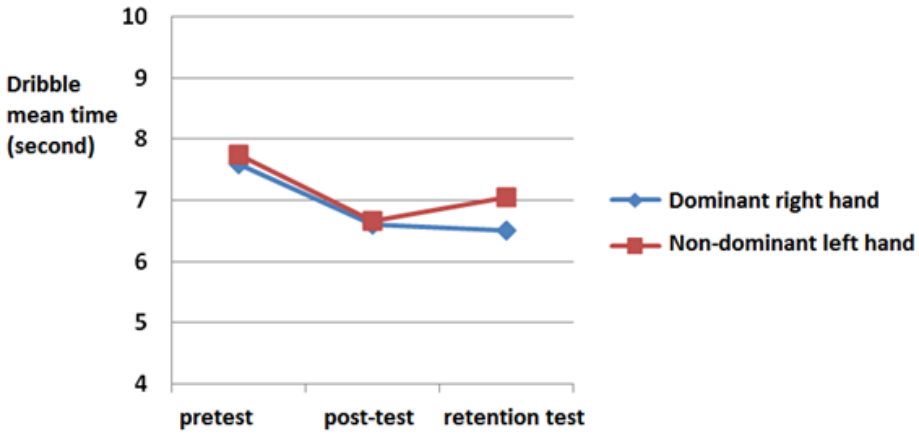

Fig. 2. The mean time of the subjects' performancewith dominant right and non-dominant left hand in group A (right hand- left hand) regarding the three tests

Fig. 3. The mean time of the subjects' performancewith dominant right and non-dominant left hand in group B (left hand- right hand) regarding the three tests

between the ball and the defender and dribble the ball using the external hand (the hand that is away from the defender).

In order to familiarize the participants with the training program and the delivery of task test, the necessary information was provided to them first. Then in a pretest, the participants did SDT once with the right hand and once with their left hand. The dribbling speed was recorded. After that in the acquisition phase, the subjects participated in 45-minute training sessions for 4 weeks (2 sessions per week). Thus, the subjects in group a (right hand-left hand) practiced first four sessions with their dominant right hand and the second four sessions with their non-dominant left hand. Group B (left hand-right hand) practiced first four sessions with their non-dominant left hand and the second four sessions with their dominant right hand. At the end of the training sessions, the subjects took a post-test in accordance with their pre-test. To investigate the relative stability of performance, retention test was delivered one week after the exercise with the same method used in the pre-test. At the same time, the subjects also participated in the transfer test.

Statistical method

In this study, descriptive statistics were used to calculate the measure of central tendencies such as the mean and standard deviation. Kolmogorov-Smirnov test was utilized to verify the normality of data.An independent t test was also used to compare performance between the dominant hand and non-dominant hand in the groups regarding the pre-test. ANOVA was used with repeated measures in a 2 (group) × 2 (hand) × 3 (stages: pre-test, post-test and retention) manner to evaluate the performance of groups at different stages of the test. Post hoc Bonferroni test was used to identify and locate the differences. In addition, in order to study the differences between the groups, independent t test was used to test the transfer.

Table 1. Analysis of variance with repeated measures to measure the performance of the subjects in different stages

Source of changes	Sum of squares	Freedom degree	Mean square	F	R
Group	5.28	1	5.29	4.28	0.052
Stage	29.72	2	14.85	38.33	0.000*
Hand	0.75	1	0.74	4.80	0.041*
Stage ×Group	0.19	2	0.09	0.24	0.77
Hand × Group	0.31	1	0.31	2.06	0.16
Hand × Stage	0.07	2	0.03	0.43	0.64
Group × hand × stage	0.74	2	0.37	4.46	0.017*

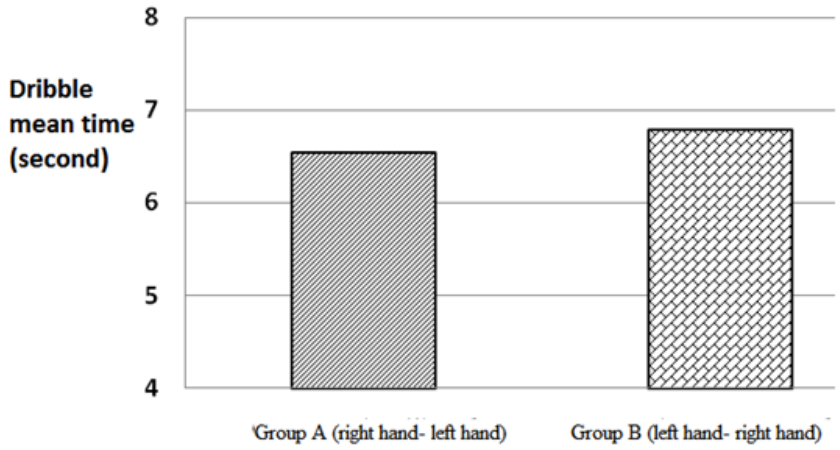

Fig. 4. The mean time of the subjects' performance in group A and B in transfer test

Table 2. Results of independent t test to compare mean performance in the groups regarding transfer task

Group	Number	Mean	SD	Freedom degree	T	P
A (right hand-left hand)	10	6.54	0.37	18	1.43	0.15
B (left hand-right hand)	10	6.79	0.38			

Findings

Figure 2 and Figure 3 show the mean time of the subjects' performance in the basketball dribbling task in group A and B. As can be seen, in both groups, movement duration has decreased significantly for the both hands from the pretest to post-test. However, there was no significant difference between the post-test and retention test. Figure[4] shows the meantime of the participants' performance in the two groups A and B in the transfer task. There was no significant difference between the two groups. Kolmogorov-Smirnov test results confirmed the normality of the data distribution ($P<0.05$). The independent t test results showed that there was no significant difference between the performance of right hand ($p=0.14$, $t=1.50$) and left hand ($p=0.16$, $t=1.45$).

The results of analysis of variance with repeated measures (Table 1) showed that the main effect of the group was not significant ($p<0.05$). There was no significant difference between the two groups performance (group A, M=7.03; group B M=7.45). The main effect of the stage was significant ($p>0.001$).Post hoc Bonferroni test results revealed that the subjects had a significantly better performance in the posttest (M = 6.81) and retention test (m = 6.97) compared to pre-test (m = 7.93) ($p>0.05$), but there was no significant difference between the post-test and retention test ($p<0.05$). The main effect was significant ($p>0.05$). The results showed that right hand (m = 7.16) significantly outperformed the left hand (m = 7.32) ($p>0.05$). The interactive impact between hand and stage groups was significant ($p>0.05$).

In group A and B, the subjects had a better performance in the posttest and retention testaspertheir right hand compared to left hand and compared to the pretest. Other interactive effects were not significant ($0.05> p$).Independent t test results (Table 2) showed no significant difference between the mean performance of transfer task in the group A (m = 6.54) and B (m = 6.79) ($p<0.05$).

DISCUSSION AND CONCLUSION

The results showed there was no significant difference between the two training groups in terms of basketball dribbling skill acquisition. Movementtime decreased from pre-test to post-test dramatically. Thus practicing with a sequence of right hand-left hand causes the acquisition of basketball dribbling skills with both dominant and non-dominant hand. Practice with the left hand- right hand sequence, as well, causes the acquisition of basketball dribbling skills with both dominant and non-dominant hand. The results show that the sequence of using dominant and non-dominant limbs in primary training methods is important to improve the bilateral performance of both limbs.

The findings also showed the advantage of dribbling with the right hand. The participants in the both groups had a shorter movement time in dribbling with right hand in post-test and retention test compared to left hand. The lack of significant differences between post-test and retention test shows that exercise has a lasting effect on the acquisition of skills in both groups with both hands.A similar pattern of results was obtained in the transfer test, and no significant differencewas observed between the two groups regarding the transfertask. Although the group A (right hand – left hand), compared to (left hand- right hand),had a shorter movement time for transfer task, the difference was not significant. The results are in line with consideredassumptions regarding the transfer of learning based on proficiencymodel. In this model, each hand can benefit from the other motor learning, andthere is no difference between starting learning with any of hands[6-7]. In their study on students, BagherZadeh et al. (1383) and BanooGhaderiet al (1384) showed that learning transfer of Short service badminton skills and basketball dribbling from dominant to non-dominant hand and vice versa is the same[3, 15].

Teixeiraet al (2000) and Lee and Carrol (2007), in their studies, found that there was no difference in learning transfer ofanticipatory timing from the dominant to non-dominant hand and vice versa[5, 16]. The findings of Hosseini et al (2013) showed training with the dominant and non-dominant leg has due tolearning transfer and improvedtask performance of side kick in soccer in both legs (with an emphasis on cognitive component of accuracy)[10]. However, our results do not match the findings of Senff&Weigelt (2011) and Stoeckel et al (2007). In their own research on elementary school students, they showed that the acquisition of task (accuracy of slide coins and basketball shooting) was facilitated after initial training by non-dominant hand, and the performance is improved with both hands for those who started the learning with their non-dominant hand[11, 15]. The results of a research by Stoeckel and Weigelt (2012) on students between 11 and 14 years also showed that tasks that require a lot of spatial accuracy (basketball throwing task) are better learned after the primary exercises with the non-dominant limb while startingan exercise with dominant limb is more effective for tasks that require maximum force production (the overarm throw in handball)[13].

The present results are also inconsistent with the findings of Stoeckel et al (2011), who investigated the acquisition of basketball dribbling skills in students between 11 and 13 years. They showed that training group (non-dominant-dominant) had a better performance in both hands compared to the training group (dominant-non-dominant) in the retention and transfer test[12]. The reasons for the differences in these findings can be noted in the age of the studied groups. These studies have all examined the performance of students aged between 11 and 14 while this research focused on students aged between 19 and 24 years. Increase of age means increase in motor experiences with both hands and priority of dominant hand in performing different tasks[17-18]. Other reasons for difference between the results may be to the difference in the type and complexity of the task, training program and its duration, measurement tools, and statistical methods used in the mentioned studies. Furthermore, according to dynamic dominance hypothesis as well as specialized hemisphere/limb model, the left hemisphere is primarily responsible for processing time control and sequence of movements, and adjusting the movement aspects. The right hemisphere is responsible for processing visual-spatial information, and controlling the final position and target precision[6, 13]. Since the acquisition of Basketball dribbling skills greatly relies on integration of visual-spatial information and also the speed of movement, performing this task with high speed and coordination of movements in space demands the adjustment of the body with external objects and events, coordination of neuromuscular system to control different parts of the body as well as coordination of degrees of freedom[12].

Considering the results of this study, it can be said that in motor learning of this skills needs to teaching spatial sequence (bypassing the cone and coordinating movements with external cones) and motor sequence (motor performance at high speeds). They are both important. Therefore, the initial involvement of the system of right hemisphere-left hand in learning the mechanism of spatial sequence in the basketball dribbling in the group (non-dominant-dominant) plays a role in the acquisition of this skill.

The findings of this research present greater insight about how to plan training sessions for the acquisition of motor skills. The ultimate goal of many trainings is to acquire a particular skill flexibly with both limbs just as it is a necessity in competitive games and sports. Thus, in their educational programs, coaches and physical education teachers should aim at more effective training and adopt a more precise approach in designing the specific task of a skill acquisition. The present study provides evidence for the effects of specific task handon the acquisition of complicated sport motor skills. It shows that practice with dominant and non-dominant limbs can be important in initial motor learning to improve the performance of both members and to reinforce the bilateral capability of learners.

Therefore, it is recommended that the same study is be performed on various age groups and both genders. Also, the study should be done on people with dominant left handand examined differences. The results of the studies will give us more information about designing of initial training programs and processes of training organization.

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