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Effect of practicing soccer juggling with different sized balls upon performance, retention and transfer to ball reception

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underskrift

Preface

I would like to thank my supervisor professor Roland van den Tillaar for his guidance and support during this work with the master thesis. I would also like to thank lecturer Tore Kristian Aune for his idea and contribution in the process. I am grateful to Sondre Nylund and Elisabeth Reppe for helping me with the data collection. A special thanks to the participants who took time out of their own training and school time to take part in this study.

Effect of practicing soccer juggling with different sized balls upon performance, retention and transfer to ball reception

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Abstract

The aim of this study was to investigate if making the acquisition phase more difficult or easier would enhance transfer and retention performance in soccer juggling, and if this practice has a positive transfer effect to ball reception performance. Twenty-two adolescent soccer players (15 females, 7 males) at the age of 16 to 19 (mean age 16.6 ± 0.93 yr.) were tested in juggling a soccer ball as many times as possible within 30 seconds using only dominant foot. In addition, the control of an approaching ball inside a restricted area was tested. After the pre-test the subjects were randomly divided in two equally sized groups. In the training period of six weeks four times per week and ten minutes per session, one group practiced soccer juggling with a smaller ball than the test ball (small ball group), making the acquisition phase more difficult, while the other group practiced soccer juggling with a larger ball then the test ball (big ball group), making the acquisition phase easier. No training consisting of ball reception was practiced during the training period. A retention-test was carried out 6-7 weeks after the post-test to investigate the persistent of the soccer juggling performance. It was hypothesized that practicing soccer juggling with the smaller ball would enhance transfer and retention performance more compared to practice with the larger ball. In addition, it was hypothesized that soccer juggling practice would not have a positive transfer to ball reception performance. The result showed that both groups enhanced transfer and retention performance in soccer juggling test with no difference between groups, thereby rejecting the hypothesis that practice with the smaller ball would be superior compared to practice with the larger ball. This result supports the variability of practice hypothesis. The author also suggests that the number of repetitions is a more important factor than the ball size practiced with in the acquisition phase. However, no positive transfer was found to ball reception performance, supporting the specificity of learning principle.

Keywords: Transfer, Retention, Soccer juggling, Ball reception, Ball size, Variability, Specificity, Repetitions

Effekten av fotballtriksing med forskjellige ballstørrelser og overføringsverdi til mottak i fotball

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Sammendrag

Hensikten med dette studiet var å undersøke om overføringsverdien og varigheten i trikseferdigheter er størst ved å gjøre treningen vanskeligere eller enklere under trening, og om denne treningen har en positiv overføringsverdi til mottak i fotball. Tjueto fotballspillere (15 kvinner, 7 menn) mellom 16 og 19 år (gjennomsnittsalder 16.6 ± 0.93 år) ble testet i å trikse en fotball så mange ganger så mulig med dominant fot i løpet av 30 sekunder. I tillegg ble ferdigheten fotballmottak testet i et avmerket område. Etter pre-testen ble subjektene tilfeldig utvalgt i to like grupper. I treningsperioden som bestod av seks uker, fire treninger av ti minutter per uke, trente den ene gruppen fotballtriksing med en mindre ball enn testballen (liten ball gruppe) noe som gjorde treningen vanskeligere. Den andre gruppen trente med en større fotball enn testballen (stor ball gruppe) noe som gjorde treningen enklere. Ingen trening som bestod av ballmottak ble trent under treningsperioden. For å undersøke varigheten av trikseferdigheten ble en ny test utført 6-7 uker etter post-testen. Hypotesen i denne studien var at triksetrening i fotball med den mindre ballen ville føre til høyere grad av overføringsverdi og varighet i trikseferdigheter sammenlignet med trening med den store ballen. I tillegg var hypotesen at triksetrening i fotball ikke ville ha overføringsverdi til mottaksferdigheter i fotball på grunn av spesifisitetsprinsippet. Resultatene viste at begge gruppene forbedret prestasjonen i triksetestene, og det var ingen forskjell i resultatene mellom gruppene. Dermed ble hypotesen at triksing med liten ball ville føre til størst overføringsverdi og varighet forkastet. Dette resultatet støtter hypotesen om variabilitet i treningen. Forfatteren foreslår også at antall repetisjoner under trening er en viktigere faktor enn å trene med forskjellige ballstørrelser. Resultatene viste også at triksetrening i fotball ikke hadde en positiv overføringsverdi til ferdigheter i fotballmottak, noe som støtter prinsippet om spesifisitet i treningen.

Nøkkelord: Overføringsverdi, Varighet, Fotballtriksing, Fotballmottak, Ballstørrelser, Variabilitet, Spesifisitet, Repetisjoner

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1. Introduction

In the area of motor skill learning it always has been of great interest to investigate the best conditions for effective learning. This has been the topic since Thorndike`s and Woodworth`s (1901) early experiments. One of the most important objectives in motor control learning is to ensure that skills practice can be adapted to new situations the learner encounter (transfer), and that once skills are learned, they are retained (retention) over a long period (Schmidt & Lee, 2005). Hence, transfer refers to the possibility to use the practiced skill in new situations, while retention refers to the persistent of learned skills.

The influence of different practice regimes on the acquisition, transfer and retention of performance have been a main subject in motor skill learning, because coaches and trainers want to have the most efficient method of teaching a skill (Magill & Hall, 1990). One option in skill learning is to make the acquisition phase easier for the learner, and thereby believe that this will enhance transfer and retention performance (Schmidt & Bjork, 1992). This seems logic, because learners achieve on a high level of performance during acquisition, and thereby this performance should pay off in transfer and retention test (Vickers, Livingston, Bohnert, & Holden, 1999). Another option is to create a more difficult learning environment that could lead to poorer performance during acquisition, but later can improve transfer and retention performance (Shea & Morgan, 1979).

In essence, there are two main theories about how to practice to enhance transfer and retention performance. The first one is the specificity of practice principle, and the other is known as the variability of practice hypothesis (Shea & Kohl, 1990).

The specificity of practice hypothesis originated from Thorndike`s "identical elements theory" (Thorndike & Woodworth, 1901), and states that transfer and retention depends on the number of identical elements that two tasks have in common (Magill, 2001). Later, this theory became known as the specificity of practice hypothesis (Henry & Rogers, 1960). The main prediction of Henry`s specificity of practice hypothesis is that abilities are independent, and only superficially resemble other tasks (van den Tillaar & Marques, 2013). However, a major problem with specificity theory is to identify what elements that must be identical to expect positive transfer between two tasks (Schmidt & Lee, 2005). For example, one important common element between soccer juggling and ball reception is the ability to keep the ball under control. If this element is identical between soccer juggling and ball reception, a positive transfer should be expected between the two tasks.

Attempts to identify which elements that must be identical to expect transfer between tasks have been illustrated when sensory (vision) information has been added ore removed at

the transfer test (Proteau, Marteniuk, & Levesque, 1992; Tremblay & Proteau, 2001). It was shown that by using a tracking and ball interception task, either removing or adding sensory information had a negative effect on test trials.

Keetch and colleagues (Keetch, Schmidt, Lee, & Young, 2005; Keetch, Lee, & Schmidt, 2008) presented further evidence for the lack of transfer between two tasks. They showed that a massive amount of practice from the foul line had led to greater accuracy from that specific distance in skilled basketball players, but did not transfer to other distances (Keetch et al., 2005). In a follow up experiment the participants shoot from the same foul line distance, but the angle was altered (Keetch et al., 2008). However again the accuracy from the foul line did not transfer to different angles. Hence, practicing from one distance had led to sensory information specificity that did not transfer to other distances and angles.

Although there is evidence that skills are highly specific, Weigelt, Williams and Wingrove (2000) found positive transfer between two tasks that apparently do not share the same elements of sensory information. In their experiment, ball reception performance enhanced by 23% due to practicing soccer juggling (Weigelt et al., 2000). In addition, O`Keefe, Harrison and Smyth (2007) found that practicing overarm throw had positive transfer effect to badminton overhead shot and javelin performance.

A possible explanation of how practicing one skill can transfer to other skills derived from schema theory and is called variability of practice hypothesis (Schmidt, 1975). According to the variability of practice hypothesis, there are two different representations for movement control. The first representation is the invariant characteristic of a movement that includes the common features among a particular class of action. These features include which muscles used to execute a movement, phasing, and forces produced in the movement (Lee, Swanson, & Hall 1991). For example, throwing a javelin and throwing an overhead ball will share the same invariant characteristic, and hence belong in the same motor program. What is different between those actions is the second representation in motor control called the parameterization schema. This parameterization schema is responsible for supplying specific movement details of a particular action. These movement details include specification such as the individual muscles or muscles group used in a movement, force, speed, range of motion and timing (Sigmundsson & Haga, 2004). Implementation of these parameters is based on the schema and the main prediction of this theory is that variability in practice strengthens this schema, which is capable of producing similar but different novel movements and enhancing transfer and retention performance (Travlos, 2010). After the release of the variability of practice hypothesis, several experiments supported Schmidt`s notion. For example Kerr and Booth (1978), Graydon and

Griffin (1996), and Vera and Montilla (2003) found evidence that variability in practice enhanced transfer and retention performance using throwing task.

However, the variability of practice hypothesis does not address the transfer and retention effects if we make the task practiced more difficult or easier in skill acquisition (Shea & Kohl, 1990). This topic is of great importance, because coaches often use practice methods that achieve high levels of performance during acquisition, but fail during later transfer and retention test (Vickers, et al. 1999). Shea and Morgan (1979) first discovered the benefit of making a task difficult in the acquisition phase to enhance later transfer and retention performance. Since the Shea and Morgan study, the learning advantages of making the acquisition phase more difficult to enhance transfer and retention performance have been replicated in several laboratory experiments (e.g. Del Rey, 1989; Hall & Magill, 1995). The main explanation for this learning paradox is the elaboration and reconstruction hypothesis. According to these hypotheses, random (more difficult) practice leads to more elaborate memory representation because participants use variable information strategies in task learning. In addition, random practice forces the learner to reconstruct every movement, adding extra degree of processing demand on the learner that could enhance transfer and retention performance (Vera, Barbero & Montilla, 2008).

Although Li and Lima (2002) found the advantage of making the acquisition phase difficult to enhance transfer and retention performance in a natural setting, several studies outside the laboratory have yielded mixed results. For example, Goode and Magill (1986) and Wrisberg (1991) found the advantage of making the acquisition phase more difficult in only one of three distances in badminton serves. However, Goodwin and Meeuwsen (1996) and Pollatou Kioumourtzoglou, Agelousis and Mavromatis (1997) found no advantage of creating a more difficult acquisition phase to enhance transfer and retention performance in a kicking and golf-putting task. Thus, there is some evidence that studies carried out in the laboratory benefit of making the acquisition phase more difficult, while studies conducted in natural setting yield mixed results.

One issue that either variability of practice or random practice addresses is the learners initial skill level. It could be that novice performers benefit of making the acquisition phase easier to enhance transfer and retention performances, while experienced performers need a more difficult acquisition phase to improve transfer and retention skills (Wulf & Shea, 2002). To account for the learners skill level the "challenge point" hypothesis was released (Guadagnoli & Lee, 2004). The main point of this hypothesis is that the functional task difficulty must be adjusted to the learners skill level if learning should occur (Guadagnoli,

Molin, & Dubrowski, 2012). In the case of soccer juggling, that means that if a learner has reached a steady level, the functional task difficulty must be altered to expect further development. The challenge point hypothesis has been supported by systematically increasing the task difficulty in acquisition phase (Porter & Magill, 2010; Porter & Saemi, 2010).

However, most of the studies investigating transfer and retention effects have altered the difficulty in acquisition phase by using blocked (easy) or random (difficult) practice (Magill & Hall, 1990). Very few experiments have manipulated the size of the used practice equipment to create an easier or more difficult acquisition phase. Thus, the first purpose in this study was to alter the size of the practice equipment to investigate the transfer and retention effect. To alter the size of the equipment one group practiced soccer juggling with a smaller (more difficult) ball then the transfer ball, while the other group practiced soccer juggling with a larger (easier) ball then the transfer ball. Based on theory about the positive transfer and retention effects on making acquisition phase more difficult, it is hypothesized that training with the smaller ball will enhance transfer and retention performance.

In addition, there is a lack of research examining transfer effect between various sport skills (O`Keefe, et al. 2007). Thus, the second aim of this study was to investigate if practicing soccer juggling would have a positive transfer effect to ball reception performance. Based on specificity theory and that it is unlikely that soccer juggling and ball reception share the same motor program, it is hypothesized that practicing soccer juggling would have no positive transfer effect to ball reception.

2. Method

2.1 Subjects

Twenty-two adolescent soccer players (15 females, 7 males) at the age of 16 to 19 (mean age 16.6 ± 0.93 yr.) were recruited for the study. Of these subjects, five dropped out of the study: one subject did not complete the required training sessions; one subject suffered an injury; and three subjects experienced an experimental error (two times the ball projector machine lost power, and one time the video camera failed) during ball reception testing. This leaves 17 subjects for ball reception performance for statistical analyses. In addition, one subject suffered an injury between post and retention test, leaving 16 subjects for further analysis for soccer juggling performance. Before participating in this study, the participants were informed about the protocol and informed consent was obtained prior to testing from the participants. The study was conducted in accordance to the Helsinki declaration.

2.2 Experimental design

To investigate if soccer juggling performance would enhance by making the acquisition phase easier or more difficult, training soccer juggling with smaller and larger ball than the test ball was the independent variable, while soccer juggling performance with the test ball was the dependent variable. To examine if soccer juggling would have a positive transfer to ball reception performance, soccer juggling with larger and smaller ball was the independent variable, while ball reception performance was the dependent variable. The experimental design was a 6-week pre- to post-test intervention design with two groups. In addition, a retention test was carried out 6 – 7 weeks after post-test (Fig. 1). The groups were matched based upon the ball-juggling task performance at the pre-test. One group (n=11) was assigned to practice juggling with a smaller ball (Select, size 1, circumference 47-48 cm, 250 gram) than the test ball. The other group (n=11) practiced juggling with a larger ball (Diadora, size 4, circumference 66 cm, 370 gram) than the test ball. Both groups participated in a 6-week training program in which only soccer juggling was practiced. The practice program consisted of 10 minutes soccer juggling training four times a week, making the total training time 240 minutes.

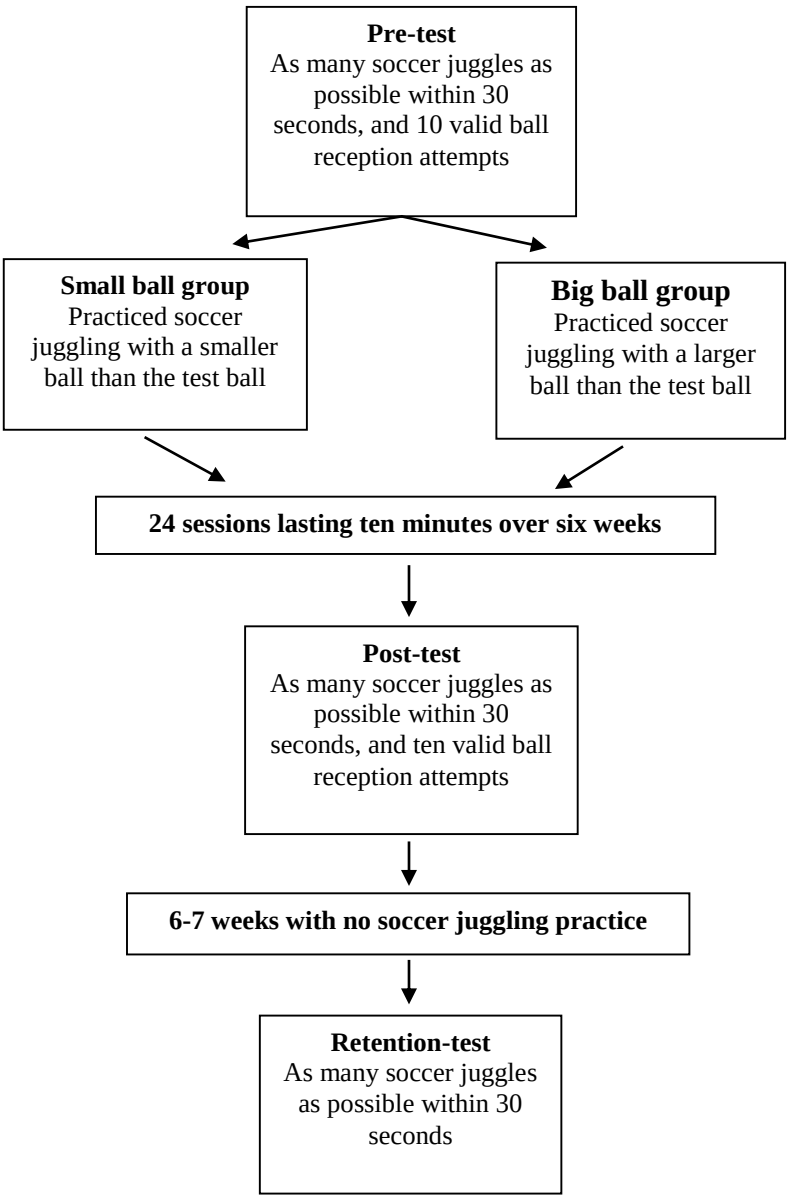

Fig. 1. Experimental design with practice program and time between pre-test-post-test and retention-test.

2.3 Procedures

Before pre-testing, a separate familiarization session was conducted to avoid a learning effect during the pre-test. This practice session included 10 practice trials with controlling the ball from a ball projection machine, and approximately 10 minutes of ball juggling with the pre-testing ball was exercised. Five days after the familiarization session, soccer juggling and ball reception testing was carried out in the same test sequence, with ball reception testing preceding the ball juggling test. The total test time was approximately 20 minutes for each of the participants. Before testing in ball reception, the participants underwent 10 minutes of warm-up consisting of running and four practice trials of reception and controlling the ball served

from the ball projector. After completing the ball reception test, the participants had five minutes of rest before the start of the ball-juggling test. All testing was conducted at an indoor sports hall on a pulastic surface (Pulastic 2000 Air-elastic). No learning strategy was given to the subjects during the intervention period, but they were required to juggle for the selected time in every practice session. The researcher was present in 50% of the practice sessions during the intervention period. In the rest of the sessions, the participants practiced on their own, but rigid guidance was given and all participants kept their own training logs. If any of the participants completed less the 20 of the planned 24 juggling sessions, they were excluded from the statistical analyses.

2.4 Apparatus and task

During the pre and post-test in ball reception the participants had to control an approaching football (Umbro Neo Focus football, size 5, circumference 71 – 72 cm, weight 450 gram, bar 0.9) inside a four-diameter area. This area was divided into one central zone, and three surrounding zones each with a radius of 50 centimeter between each other (Fig. 2). The purpose of these zones was to assess performance in later analyses. After the warm-up procedure, the participants stood in the center of the marked zone. A ball projection machine (Soccer Tutor by Sports Tutor) shoot a ball over a distance of 10 meters in a straight line with a speed between 13.89 m/s to 15 m/s (Mean and SD calculated from 40 test trials with the ball projector machine: 14.44 ± 0.28 m/s.). The speed of the ball was measured with a Doppler radar gun (Sports radar 3300, Sports Electronics Inc.) before the pre-test. To record the reception performance, two Sony Handy Camera HD AVCHD were used. The position of camera one was 3.5 meters high and four meters in front of the subjects. Camera two was placed 3.5 meters high and 3 meters behind the subjects, making the performance possible to assess wherever the ball stopped. A signal was given before the ball projector released the ball, and the participants task was to control the ball with preferred leg and stop the ball as quickly as possible. A valid attempt was given when the participants was able to control the ball inside the marked area. Between every attempt, the participants had 20 second of resting time. The participants underwent ten valid attempts in pre and post-test.

During the pre-, post- and retention tests in soccer juggling the subjects juggled a football (Nike CTR360 Technique Fotball size 3, circumference 62 cm, weight 320 – 340 gram, bar 0.8) inside a marked area of four diameter (Fig. 2). A Sony Handy Camera HD AVCHD was used to record the juggling performance. The camera was placed 3.5 meters high, and 3 meters in front of the participants. The subjects were instructed to juggle the ball as many times

as possible within 30 seconds with their dominant leg, using only the instep part of the leg. A four-diameter designated area marked where the participants could move around. The participant completed five attempts of 30 seconds, and the average of the three best scores was taken to further analysis.

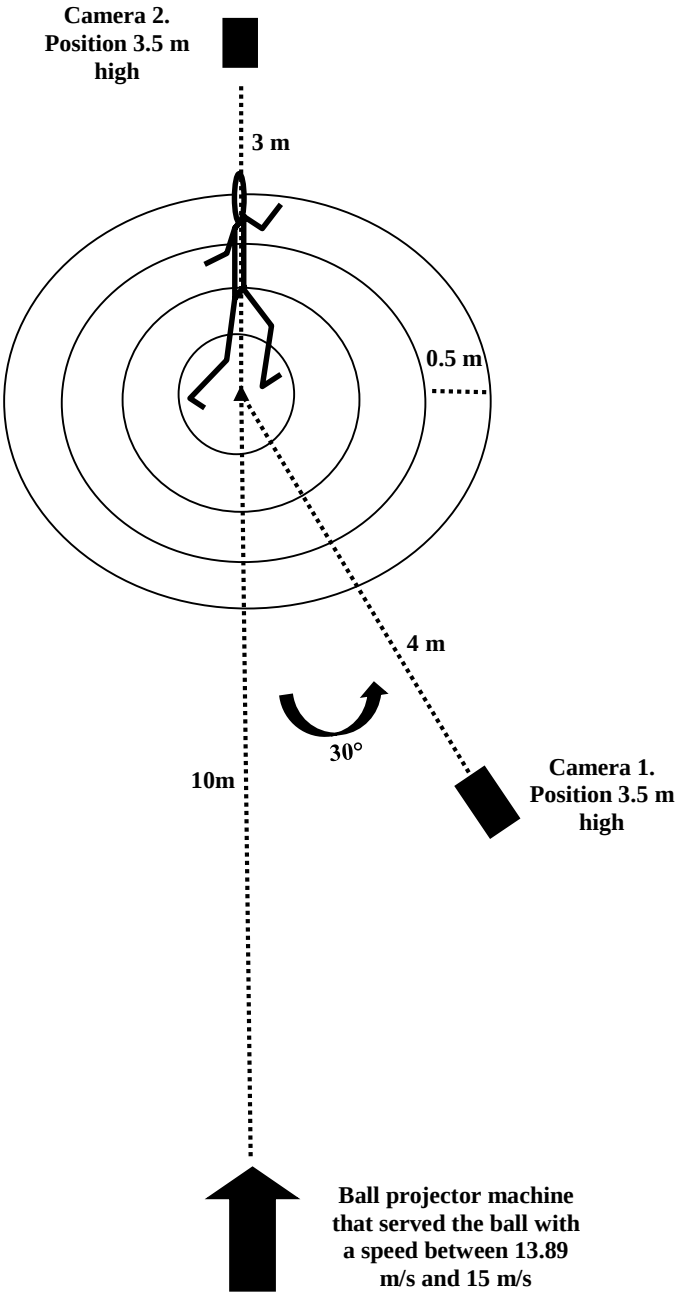

Fig. 2. View of reception and juggling area and measuring apparatus.

2.5 Analyses

Kinovea analyses program (version 08.15) was used to assess performance in soccer juggling and ball reception. To assess soccer juggling performance, only touches using the dominant and instep part of the foot were counted. To assess ball reception performance, the time between first touch and control (measured in a hundredth of a second), and the distance between first touch and control were calculated (measured in cm.). The analyses where performed three times with one week in between to examine the accuracy of the measurement. ICC analyses showed that the accuracy in measurement in time between first touch and control was 0.99 and 0.98 for distance between first touch and control.

2.6 Statistical Analyses

Statistical analyses were performed using the SPSS software, version 21.0 (Statistical Package for Social Science, Chicago, IL, USA). Results are presented as mean ± SD unless otherwise stated. Shapiro Wilk Test of Normality was applied to check if the data was normally distributed. To compare the effects of the training protocols, a two-factor mixed factorial ANOVA was used with training group as the between subjects factor (smaller vs. bigger ball training) and with repeated measures on test occasion as the within subjects factor (pretest, posttest, retention test). Bonferroni adjustment for multiple comparisons was applied in further pair-wise comparisons between the three points of time. A one-way ANOVA was performed to check for differences in ball reception performance from the pre- to post-test. Gain-scores, i.e. posttest-pretest, were calculated for time between first touch and control, and distance between first touch and control. These gain-scores was used as dependent variables in two separate analyses, while training group (smaller or bigger ball), was used as the independent variable in both analyses. The general linear models univariate command in SPSS was used, in order to get the intercept as an estimate for change over time for all subjects pooled. In all tests, $p<0.05$ was used as the level of significance differences.

3. Results

Ball juggling performance increased significantly over the three test occasions ($F_{2, 28}$ = 13.89; p< 0.001), but no main effect of group ($F_{1, 14}$ = 1.01; p = 0.33) and no interaction between time and group ($F_{2, 28}$ = 0.58; p = 0.57; Fig. 3) was found. Post hoc comparison showed that performance in ball juggling increased from pre to post-test (diff.: + 4.2 ± 1.0; p = 0.003), but there was no change in performance between post-test and the retention test (diff.: -1.2; p = 0.372). The overall increase between pretest and retention test was 3 soccer juggles. (p = 0.002; fig. 3).

No significant differences between pre-test and post-test were found for ball reception performance after the training period: time between first touch and control ($F_{1, 17}$ =1.621; p< 0.22) and distance between first touch and control ($F_{1, 17}$ = 0.261; p< 0.68) as shown in fig 4 and 5. Furthermore, no group effects were found for time between first touch and control (($F_{1, 17}$ = 0.013; p< 0.91) and distance between first touch and control ($F_{1, 17}$ = 0.090; p< 0.77).

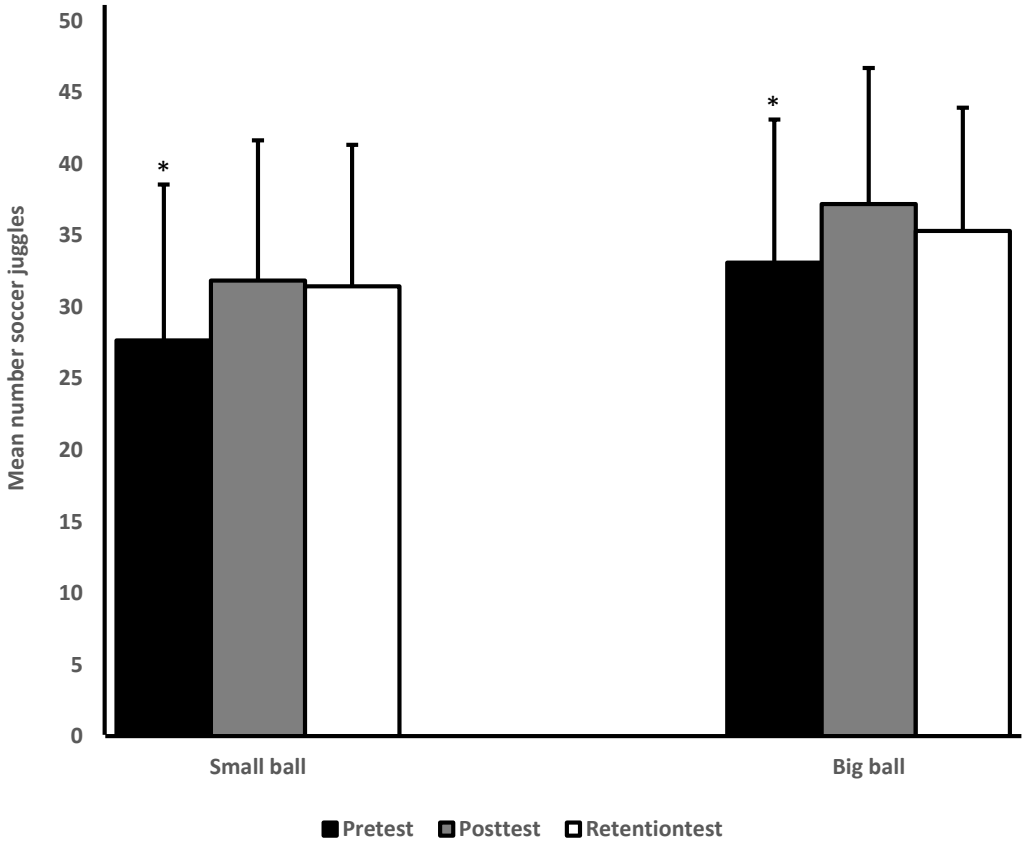

Fig. 3. Mean changes in soccer juggling transfer performance for small and big ball before and after 6 weeks of practice and 6-7 weeks of retention time. (Small ball: N=9, mean and standard deviation) (Big ball: N=7, mean and standard deviation) *= significant difference from pre-test to all other tests on a p<0.05 level but no change between post-test to retention test for either group (p=0.372) *p<0.05

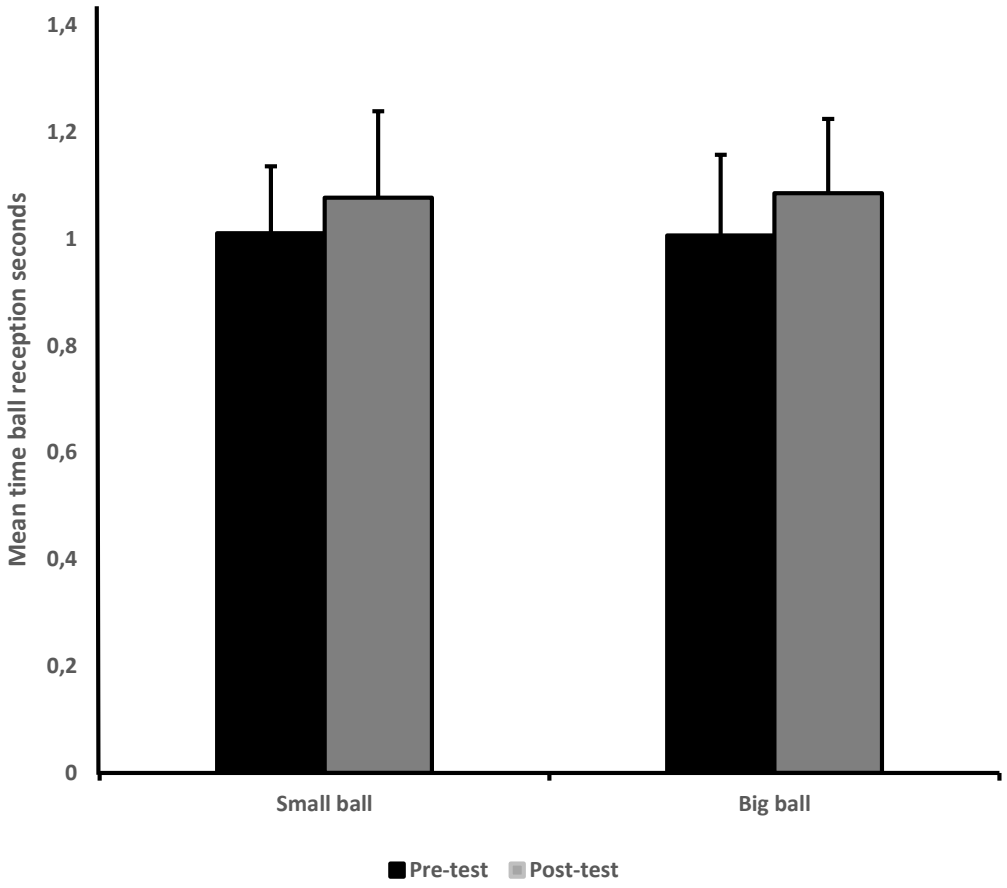

Fig. 4. Mean changes in ball reception performance: time between first touch and control before and after 6 weeks of soccer juggling practice with small and big ball. (Small ball: N=8, mean and standard deviation) (Big ball: N=9, mean and standard deviation). No significant change in ball reception performance within groups ($p=0.91$) and no significant change between groups ($p=0.22$) $p<0.05$.

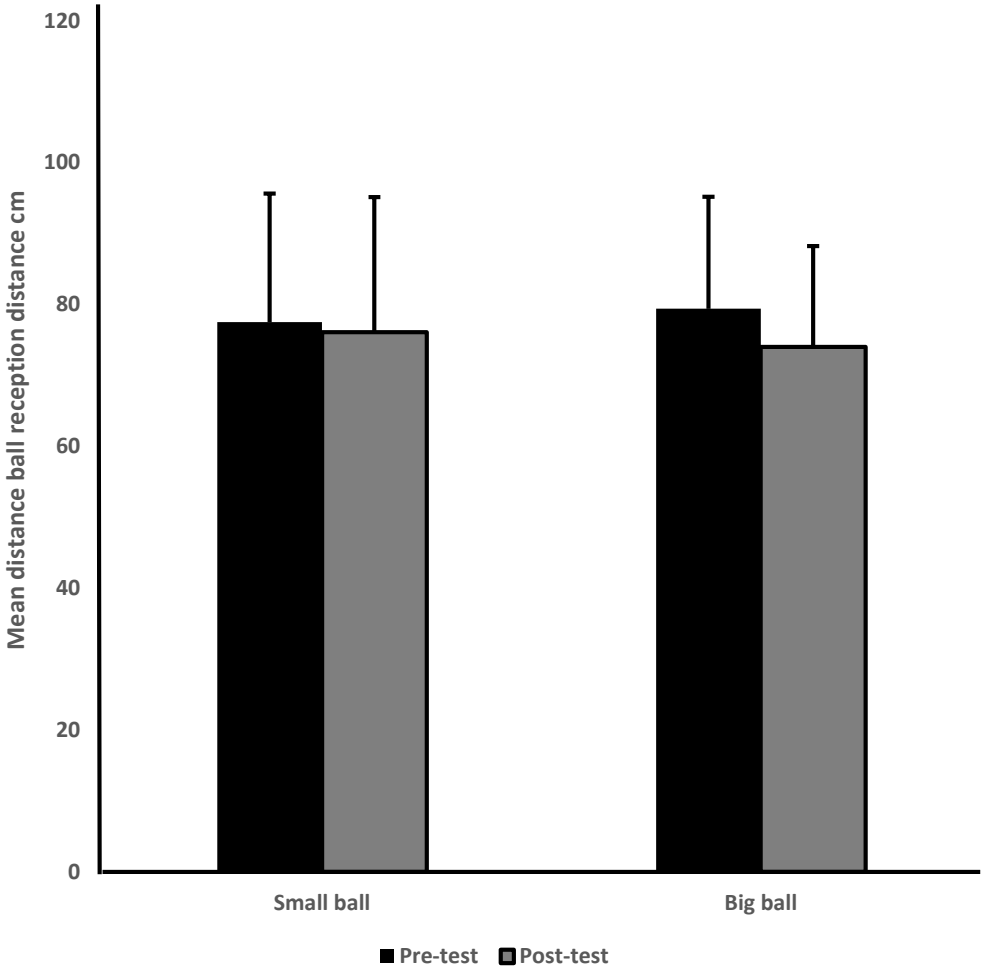

Fig. 5. Mean changes in ball reception performance: distance between first touch and control before and after 6 weeks of soccer juggling practice with small and big ball. (Small ball: N=8, mean and standard deviation) (Big ball: N=9, mean and standard deviation). No significant change in ball reception performance within groups (P=0.77) and no significant change between groups (p=0.68) was detected. $p<0.05$.

4. Discussion

This study investigated the effect of practicing soccer juggling with two different ball sizes and if this practice has a positive effect on ball reception performance. The main findings were that one: Practicing with a smaller and bigger ball both enhances performance in the soccer juggling transfer test with no significant difference between groups. Two: Both groups retained soccer juggling performance after 6-7 weeks absence of practice, indicating that learning over time did occur. Three: Enhancing performance in soccer juggling had no positive effect in the ball reception task.

The result in the transfer and retention test was not in line with earlier studies indicating that adding difficulty in the acquisition phase to enhance transfer and retention performance would be superior to simplifying the task (e.g. Shea & Morgan, 1979; Li & Lima, 2002). Hence, if adding difficulty in the acquisition phase and thereby providing extra cognitive processing activities on the learner, which is important for transfer and retention performance, both practicing with small and big ball provide sufficiently difficulty on the participants. Thus, when designing practice methods to enhance transfer and retention performance, task complexity should be a considerate before making the acquisition phase more difficult. According to Wulf and Shea (2002), there is no benefit of making the acquisition phase more difficult if task complexity is high enough. Although a discussion on this topic is difficult, soccer juggling clearly distinguishes from for example Shea and Morgan`s study (1979), where participants improved performance after as little as 54 practice trials. In soccer juggling the participants must control a moving object, while coordinating the lower limbs and using optical information from the ball trajectory. It could be argued that these task demands provide enough difficulty in the acquisition phase, and adding extra difficulty to the task was not necessary to enhance transfer and retention performance.

Thus, the results in soccer juggling support the variability of practice hypothesis, claiming that practice variability within the same motor program will enhance transfer and retention performance to a novel variation of the task (Schmidt, 1975). This theory provides a plausible explanation for the results, because practicing a variation of the task leads to a stronger generalized motor program that enhances performance in a novel task. This was in line with earlier studies using upper limb tasks (e.g. Graydon & Griffin, 1996; Kerr & Booth, 1978; Travlos, 2010) like the accuracy in bean bag throwing and volleyball serving. Hence, it`s likely that practice soccer juggling with different ball sizes developed important movement parameters like timing (the ball trajectory and the movement of lower limb) and force production (forced produced by the lower limb to control the ball) that enhance transfer and

retention performance. The absence of significant differences between groups in transfer and retention performance indicates that these movement parameters developed during the practice period regardless of ball size.

Although the variability of practice theory to some extent can explain the result in transfer and retention performance, it does not directly predict how skills can retain over a relative long period (Shea & Kohl, 1990). In earlier studies the interval between post and retention test in experiments investigating retention of skills varied normally between 2 days (Matsouka et al, 2010), 10 days (Shea & Morgan, 1979) and up to two weeks (Vera & Montilla, 2003). In this study, the interval between post and retention test was 6-7 weeks. Thus, alternative explanations for the result could be possible, and recent experiments have focused upon number of repetition in the acquisition phase as the most important factor for transfer and retention performance. For example, van den Tillaar and Marques (2013) found no significant difference between subjects practicing with different ball sizes when total workload was calculated. Although this study investigated velocity and distance in throwing performance, the results suggest that the increased workload during acquisition phase is the most important factor in transfer performance. Overlearning provides a similar explanation for the results. Overlearning refers to additional training beyond that required for initial proficiency and follows the logic that the number of repetitions in the acquisition phase is the key ingredient for transfer and retention performance (Driskell, Cooper, & Willis, 1992). A key issue is that motor skill learning does not follow a linear curve, but rather stepwise making a development plateau. This means that a lot of repetitions are necessary to progress to a higher skill level, and thereby enhance transfer and retention performance. In this study, the acquisition phase consisted of 24 sessions lasting ten minutes over six weeks giving numerous repetitions in the juggling task. It is likely that this extensive practice period strengthen the link between stimuli and response in the soccer juggling task, and thereby enhancing transfer performance and decreasing the likelihood that this skill would be forgotten. This explanation follows the "theory of neuronal group selection" presented by Edelman which states that practice strengthens the neural pathways used in the specific movement (Sigmundsson & Haga, 2004). In addition, numerous repetitions in the acquisition phase gives the learner more confidence in his or her performance, and decreases factors like stress and anxiety in a testing situation (Arthur, Winston, Stanush, & McNelly, 1998).

An important consideration in this discussion is that workload was calculated in time, and not in number of repetitions per session. This means that the total number of repetitions in the practice period depended on the practiced ball size, - motivation, - and the skill level of each

subject. Testing showed that the subjects on average juggled five repetitions more within 30 seconds with the big ball compared to the small ball. Multiply this number to the entire intervention period and there will be a significant difference in soccer juggling repetition between small ball group and big ball group. Hence, if total workload included number of repetition per session instead of ten minutes session, it is likely that the group practicing with the small ball would experience additional ball juggling repetition, and thereby perform better in transfer and retention tests. In addition, the subjects were not always under the control of the researcher between post and retention test. In this period, the participants started preseason soccer practice for a new season. Thus, it can`t be excluded that the subjects performed practice in this period that affected the retention results.

The results also showed that an improvement in ball juggling skills did not have any positive transfer effect in ball reception performance in the measured parameters. This result contradicts earlier finding by Weigelt et al. (2000) that reported 23% improvement in ball reception as a result of ball juggling practice. Two plausible explanations for this contradicting result could be firstly the different parameters used to measure transfer effects, and secondly that the participants in this study did not underwent any ball reception practice in the intervention period. In fact, several of the participants in this study decreased ball reception performance from pre- to posttest, indicating that retention loss of skills could occur (Schmidt, 2005).

Thus, the results in ball reception tests supports our hypothesis that no positive transfer can be expected when tasks do not share the same motor program. Soccer juggling requires a cyclical movement to control the ball while ball reception task requires the subjects to perform a discrete movement. In addition, the timing characteristic differs markedly between soccer juggling and ball reception, and therefore it is unlikely that the two tasks share the same motor program.

These findings were also in line with the specificity of practice hypothesis that predicts skill are independent of each other, and that improvement in one skill does not transfer to other skills (Thorndike & Woodworth, 1901; Tremblay & Proteau, 2001). Although, a common element between the two tasks is the ability to keep the ball under control, several important elements differ in the two tasks. For example, studies by Proteau, et al. (1992) and Tremblay and Proteau (2001) have shown that altering afferent information between acquisition and transfer test, have a decreasing effect on transfer performance. This could indicate that learning of skills involves specific afferent information available during acquisition that is essential for movement control. In essence, this means that positive transfer between two tasks cant`t be

expected if they don't share the same afferent information. In the ball juggling task, the learner has constantly afferent information about the balls path, and can adjust the coordination of the lower limb between every trial. In opposite, the ball reception task does not provide any afferent information since the participants do not control the trajectory of the ball. Hence, it is likely that the differences in afferent information between soccer juggling and ball reception prevents positive transfer between the two tasks.

Furthermore, the fact that no transfer between soccer juggling and ball reception was found, supports Henry`s (1960) view that the number of motor abilities is very large and independent of each other. Therefore, it could be argued that difference in movement characteristic between soccer juggling and ball reception prevents transfer between the two tasks. Hence, strengthening the ability to perform soccer juggling is unrelated to the abilities supporting ball reception performance.

However, an important issue in this discussion is that the ball size used in soccer juggling practice was not the same size as in ball reception testing. The fact that different ball sizes were used contradicts the specificity of practice hypothesis that says every element must be identical to expect positive transfer between two tasks. Thus, it cannot be excluded that positive transfer between soccer juggling and ball reception could occur if the ball size used in soccer juggling practice was the same as in the ball reception test.

In summary, the findings of the current study indicates that when focusing upon transfer and retention of soccer juggling skills, making the acquisition phase easier ore more difficult is a less important factor then the number of repetition in practice when the tasks share the same motor program. In addition, when two tasks differ in afferent information and movement characteristics, no positive transfer can be expected.

5. Further research and practical implications

In this study, like most of the studies investigating transfer and retention performance have used two-dimensional video analyses to measure performance. However, to get a deeper understanding of the different factors determining transfer and retention performance other measurements can be used. For example a three-dimensional kinematic motion system will provide more detail information of the subject`s coordination pattern during testing. Further studies investigating transfer and retention performance should use three-dimensional kinematic motion system to get a deeper understanding of transfer and retention performance. In addition, further studies altering the training equipment to investigate transfer and retention performance should include number of repetition in acquisition phase as total workload, and not time per session.

The main practical implication of this study is that when skills belong to the same motor program, the main factor enhancing performance is the number of repetitions in the acquisition phase. This means that coaches and trainers should create a learning environment that allows for numerous repetitions in the acquisition phase to enhance performance. Perhaps this could apply for all ball sports like handball, basket and volleyball. Further research should investigate if number of repetitions in the acquisition phase is the main factor for enhancing transfer and retention performance in other ball sports. In addition, when practicing skills that do not share the same motor program or sensory information, no transfer can be expected. Thus, specific practice is needed to progress to a higher skill level in soccer juggling and ball reception.

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