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❖ SPORT AND PERFORMANCE

EFFECTS OF TRAINING DISTRIBUTION ON RECEIVE SKILL LEARNING IN 6 YEARS OLD BOYS AND GIRLS

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Abstract

Introduction. the advantage of distributed practice upon massed one is well documented in the context of motor learning; however there is lack of understanding regarded to the preschool children. The rate of learning increase via distributed practice varies with the complexity of the practiced task. Additionally, no study has investigated the effects of training distribution upon children's' skill (receive) learning in real conditions and we have implemented measuring skill transfer rate in playing situation.

Methodology. 24 volunteer healthy nonathletic girls (age: 6.38±0.35 yrs, height: 105.21±7.19 cm, weight: 21.31±2.33 kg) and also 24 boys (age: 6.32±0.41 yrs, height: 110.37±4.56 cm, weight: 21.96±2.48 kg) participated in distributed or massed training protocols within four separated groups(girls or boys with massed or distributed practice) in 12 training sessions after receive scores (based on Olerichk's test subscale) and also skill transfer rate scores(in a local handball like game) was measured at pre test. The massed training was included on 36 repetitions in each session (12 sessions; 3 per week) which was divided into 2 parts each session (18 reps every part) by 2 hours rest in between the parts. The distributed training was similar to the massed one, however; each training part was divided to three 6 repetition subparts by 2 min rest in between them. The acquire test was performed 48 hours after the end of final session and remember test was repeated on one week later. There were also post test for the skill transfer rate at one week after than the final training session. Multivariate ANOVA, Univariate ANCOVA, ANOVA for repeated measurements and paired sample t tests was used to compare the data at statistical significance level equal to 0.05.

Results. There were significant within group differences in all the groups with regard to receive score between learning phases (pre test, acquire, remember phases respectively), however; no advantage was observed for any training distribution order ($P<0.05$). The skill transfer rate (local game score) also had significantly changed in all groups between pre to post test ($P<0.05$). A significant effect was only seen for the sex with regard to the between groups rate of improvements (in between pre to post test) in skill transfer rate ($P<0.05$).

Discussion and Conclusion. The use of both training distribution order has no advantage against together during receive learning for the children in acquire or remember phases. Therefore, the massed protocol could be preferable because of less time requirement. It is proposed to use massed practice for boys and on the other hand distributed practice for the girls, in order to more skill transfer rate to be accomplished to the game/match/play situations. However, more well controlled studies remained to be done because of less evidences is available in this area and the novelty of this context for children researches.

Key words: Receive skill Learning, Children, Training Distribution, Learning Transfer

Introduction

Researchers have published a number of studies that investigate how motor skill learning and memory are affected by the structure of practice. Much of this work was designed to test the schema theory of motor learning; schema theory addresses how motor skills are represented in memory and how the degree of variation in practice influences cognitive and behavioral components of learning.

It has been demonstrated repeatedly that learners whose practice trials are distributed across multiple sessions over the course of two or more days perform better than do learners who practice the same number of trials in one session (massed practice) (T.K. Dail, R.W. Christina, 2004; J.J. Donovan, D.J. Radosevich, 1999; T.D. Lee, E.D. Genovese, 1988; T.D. Lee, L.R. Wishart, 2005; C. H. Shea, Q. Lai, C. Black, J.H. Park, 2000). The benefits of distributed practice over massed practice with continuous motor tasks (i.e., balancing tasks and ski-simulator tasks) have been consistently observed (for meta-analyses, see J.J. Donovan & D.J. Radosevich, 1999; T.D. Lee & E.D. Genovese, 1988). The superiority of distributed practice over massed practice (i.e., tasks that have a clear beginning and end, as with sequences of key presses and golf putting) has been less consistently observed in learning discrete motor tasks.

No well-defined theory exists in the motor learning literature that explains why distributed practice enhances learning more than massed practice, although several researchers have suggested that learning is enhanced by biological processes that occur during rest intervals between practice sessions (T.K. Dail, R.W

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Christina, 2004; C.H. Shea et al., 2000; P.A. Shewokis, 2003). These biological processes, termed *memory consolidation*, are neurophysical changes that occur in the brain during rest intervals between practice sessions. These changes lead to enhancements in skill performance.

J.J. Donovan, D.J. Radosevich (1999) suggest that the benefits of distributed practice may be mediated by the learners' initial levels of skill on the task to be practiced and also the extent to which distributed practice enhances learning is mediated by task complexity.

In a meta-analysis of 63 experiments that studied the effects of distributed practice on learning, they found that distributed practice enhances learning in tasks of lower complexity to a greater extent than that observed with tasks of higher complexity.

The majority of extant studies have examined distributed practice effects using tasks identified as having low/average mental requirements and low overall complexity (according to Donovan and Radosovich's classification scheme). J.J. Donovan and D.J. Radosevich (1999) also found that optimal rest interval durations exist for tasks of different complexities. Simpler tasks benefit from shorter rest intervals between practice sessions, whereas more complex tasks benefit from longer rest intervals.

Unfortunately, there is lake of information about the effects of training distribution on fundamental skills development in the pre school ages for the boys and girls.

Based on the continuous physical, cognitive or emotional development during this period, different expected motor performance masterkiness level between to sexes and also with regard to the different development pattern in between them, therefore; we speculated whether the results of the existing literature in the adult populations with regard to the effect of training distribution on fundamental skills learning could be generalized to the preschool ages or not.

Moreover, we assessed the effects of training distribution upon the amount of receive skill learning transfer to the real conditions (a local classic game) which can be account as a pioneering work for the future studies.

Methodology

24 healthy sedentary volunteer girls (age: 6.38±0.36 yrs, height: 105.21±7.19cm and weight: 21.31±2.33kg) and 24 boys (age: 6.32±0.41yrs, height: 110.37±4.56cm and weight: 21.96±2.48kg) participated in massed or distributed training sessions after a pre test data collection for both receive skill (based on Olerikh's test subscale for receive in under waist, abdomen and chest levels) and skill transfer to real condition (a local classic game).

The massed training was included on 36 repetitions in each session for 12 sessions (3/week) which was executed in the two parts (18 reps every part) each session by 2 hours rest interval in between. The distributed training was similar to the massed one, however; every training part was divided to three 6 repetition subparts by 2 min rest intervals in between. The subjects were trained separately to avoid observational learning.

The transfer rate measurement (local game) was included on three 2 min game (a handball like game which emphasizes on the count of ball passes between team members within a certain time duration) periods (two people in each team) by 15 min rest in between.

The ratio of the successful receives divided to the total ball passes send from the teammate was recorded as the transfer rate score. The receive skill measurement was repeated at the 48 hours after the last training session (for acquire phases assessment) and one week later (remember test). Post test for the transfer rate was only repeated 48 hours after the last training session.

It should be noted that the tests sessions and the transfer rate game was recorded by high speed camera from thee corners(backward left, forward right and side from 2.5 meters altitude) and the scores were marked later by three different experts(mean score was set as the final score).

It is also of note that at first a consensus letter was signed by the parents and 4 subjects left the study during 2th, 5th and 10th weeks of the study.

Statistical analyze: after assuring normal data distribution order in all the cases, between groups differences in receive scores and transfer rate in pre test was assessed by 2×2 Multivariate ANOVA (2 blocks for the both sex and training distribution) at first. Thereafter, ANOVA for the repeated measurements was used to compare receive scores in three phases (pre test, acquire and remember phases).

The transfer rate scores in pre and post test was also compared using paired sample t test. Finally, the differences observed in receive skill score in between the three phases (between pre test to acquire, pre test to remember, and acquire to remember phases respectively) were compared using 2×2 Multivariate ANOVA.

Additionally, the differences observed in between pre to post test for the skill transfer rate (local game's score) were compared using 2×2 Univariate ANCOVA (performing covariate analyze about the interaction effect). All of the tests were performed with statistical significance level equal to 0.05.

Results:
The subjects' physical characteristic is shown in Table 1.

Table 1: subjects physical characteristics

Group	Weight	Height	Age
Girl Distributed training	21.76±3.01	110.58±6.24	6.36±0.25
Girl Massed training	21.69±3.03	109.3±7.68	6.45±0.26
Boy Distributed training	21.54±3.23	106.27±6.52	6.49±0.31
Boy Massed training	20.86±2.37	106.18±5.75	6.47±0.28

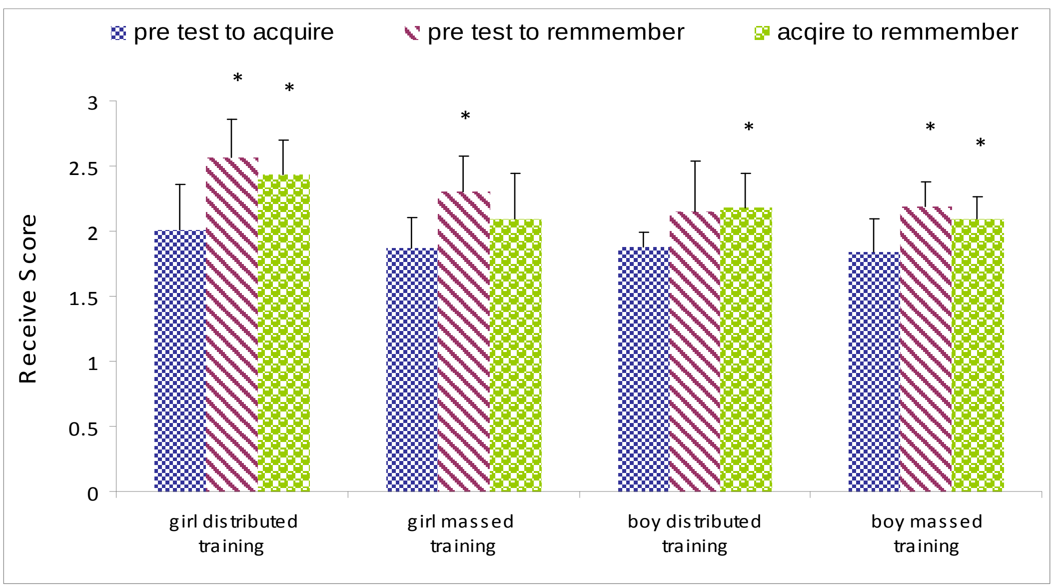
There were no between group differences in receive score or skill transfer rate score in pre test based on 2×2 Multivariate ANOVA (Table2).

Table 2: The results of 2×2 Multivariate ANOVA to compare between groups differences in receive scores and transfer rate in pre test

factor	Score of	df	Mean square	F	sig
sex	Receive (Olerikh test)	1	0.070	1.074	0.306
	Skill transfer	1	0.000	0.166	0.686
Training distribution	Receive (Olerikh test)	1	0.089	1.360	0.250
	Skill transfer	1	0.001	1.053	0.311
Interaction of the sex With training distribution	Receive (Olerikh test)	1	0.027	0.420	0.521
	Skill transfer	1	0.006	7.281	0.010 *

*: significant difference (p<0.05).

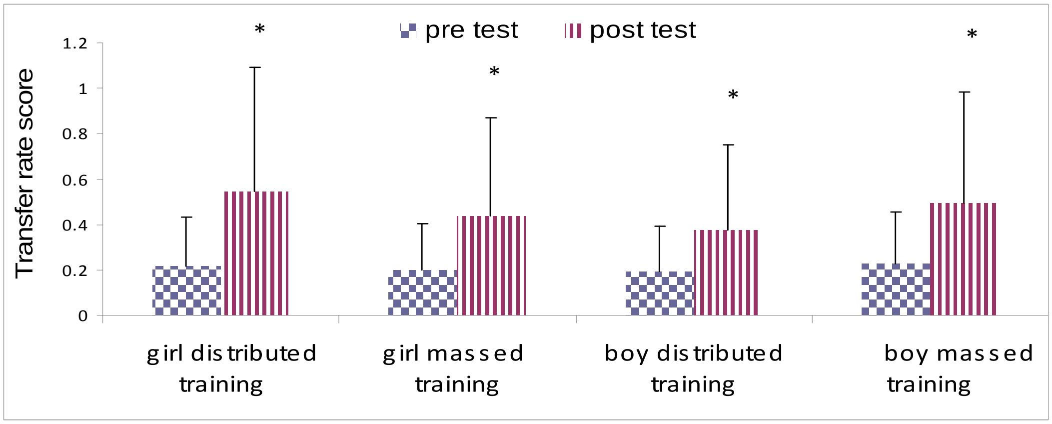
However, significant interaction between sex and training distribution with regard to the skill transfer rate forced us to use it's values in pre test as a covariate factor for the comparison(Table3) of between groups' differences observed in between three phases of the training(between pre test to acquire, pre test to remember, and acquire to remember phases respectively) Significant within group differences was observed in receive score in between three phases of the training based on ANOVA for repeated measurements (Fig 1).



*: Significant difference with regard to pre test in the same group according to ANOVA for repeated measurements (P<0.05).

Figure 1: the receive score in each group during three phases.

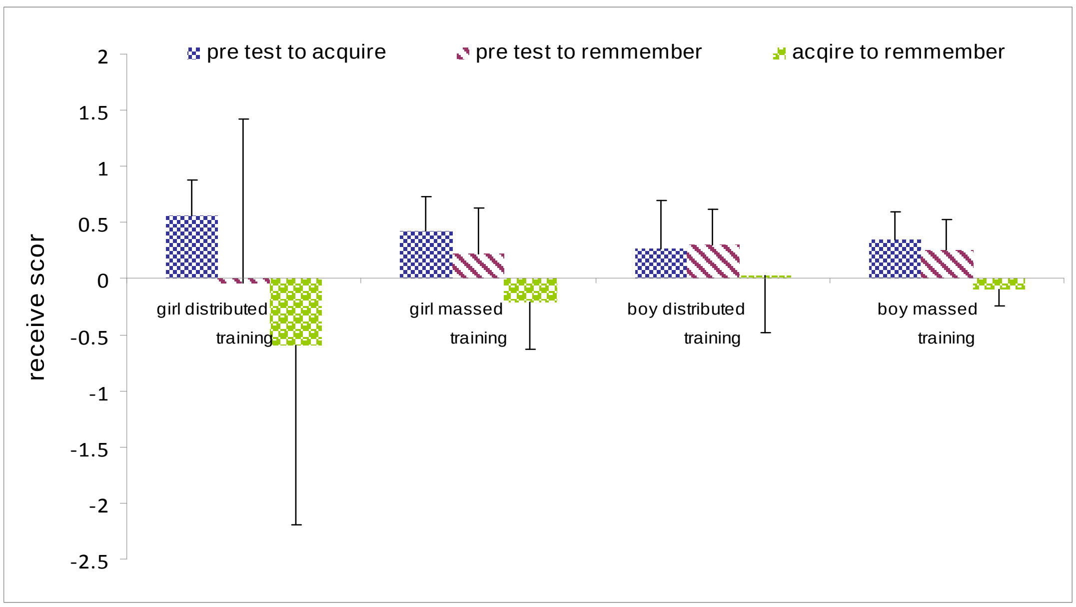
There were also significant within group differences in the skill transfer rate score in between pre test to post test (Fig 2).



*: Significant difference with regard to pre test according to paired sample t test (P<0.05).

Figure 2: The transfer rate scores of each group in pre and post test

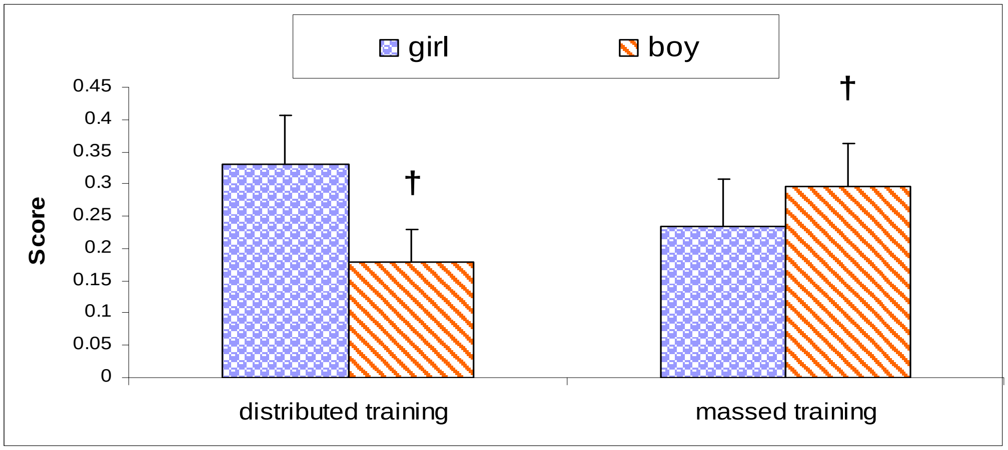
No significant between group differences was observed for the amounts of differences observed in receive score in between three phases of the training (Fig 3).



No significant difference observed based on 2×2 Multivariate ANOVA.

Figure 3.Each group's receive scores differences in between the phases

Finally, the differences observed in between pre to post test for the skill transfer rate were compared using 2×2 Univariate ANCOVA considering skill transfer rate score at pre test as a covariate factor(Table 3). Figure 4 shows that in the massed practice the rate of transfer was higher in boys and in the distributed one, the girls have had more improvements



†: Significant differences with regard to the girls according to Multivariate ANOVA (p<0.05).

Figure 4: The differences of each group's transfer rate scores between pre to post test

Table 3: The results of 2×2 Univariate ANCOVA to between group compare the differences observed in between pre to post test for the skill transfer rate

factor	df	Mean square	F	sig	Post hoc in between	Mean difference	sig
sex	1	0.040	8.041	0.007 *	Boy-girl	0.054±0.022	0.007 *
Training distribution	1	0.001	0.028	0.867	-	-	-
Interaction of the sex with training distribution	3	0.004	0.832	0.485	-	-	-
Sex × skill transfer rate in pre test	1	0.004	0.882	0.354	-	-	-
training distribution × pre test Skill transfer rate	1	0.002	0.309	0.582	-	-	-
Sex × training distribution × pre test Skill transfer rate	1	0.00	0.026	0.873	-	-	-

*: significant difference (p<0.05).

Discussion

The amount of the differences in receive skill transfer rate (score) between pre test to post test was not differed between distributed by massed training which was in contrary by the previous literature. Most of the human motor learning studies have shown that the training distribution can provide more improvements in motor performance specially 24 hours after the end of the training in comparison with massed training (T.K. Dail, R.W. Christina, 2004; J.J. Donovan, D.J. Radosevich, 1999; T.D. Lee, E.D. Genovese, 1988; T.D. Lee, L.R. Wishart, 2005; C. H. Shea, et al., 2000). It seems that these non significant differences between distributed and massed training groups can be explained by the learners (6 years old boys and girls) similar masterkiness in receive performance and development rate. It should be noted that there were no differences in receive scores based on Olerikh's criteria in pre test. Therefore, this finding is in line with the results of J.J. Donovan & D.J. Radosevich (1999) which have reported benefits of distributed practice may be mediated by the learners' initial levels of skill on the task to be practiced. Moreover, according to the other results of J.J. Donovan, D.J. Radosevich (1999) which have showed the extent to which distributed practice enhances learning is mediated by task complexity, it seems that because of the difficulty of the receive skill for 6 years old children, the rest intervals between distributed practice in this study probably would not sufficient to provide significant differences between massed by distributed practices. Therefore, identification of the most appropriate rest periods in between distributed practice protocols to provide the best improvements in performance remains to be done in the future studies.

On the other hand, there were no significant differences between groups regarded to receive score observed in between acquire to remember phases. In an effort to explain *why* distributing practice across time enhances performance skill and memory more than massed practice, researchers in human movement have drawn upon explanations first proposed by psychologists (for reviews, see H.A. Lechner, et al., 1999; J.L. McGaugh, 2000), which suggest that enhancements in performance are behavioral manifestations of neurophysical changes in the brain during rest intervals between practice sessions. These biological processes, identified as *memory consolidation*, have yet to be clearly defined; however, it is now widely accepted that acquiring new motor skills and forming memories for those skills elicit structural and functional reorganization in the brain (M.P. Walker, R. Stickgold, 2006). A time course for skill acquisition and memory consolidation has been consistently demonstrated in neuroscience literature that examines simple motor skill acquisition and performance in a population of learners who have no prior experience with the task they are asked to learn.

Observed patterns of neural activity change over time as learners engage in skill acquisition. Learners experience a rapid improvement in skill execution when they first engage in practice of a new motor skill (S. Fischer, et al., 2002; A. Karni et al., 1998; M. Korman, et al., 2003; M.P. Walker, et al., 2003). As these rapid improvements occur, neural activity that guides motor activity is modified (A. Floyer-Lea, P.M. Matthews, 2005). Neurons that fire together during repeated practice of a new motor skill begin to fire together more easily so that existing pathways become readily activated as practice continues (A. Karni et al., 1998; J.A. Kleim et al., 2004; M.P. Walker, 2005). Rapid improvements level off during acquisition practice, and performance gains are incremental by the end of the session. The refined pattern of neural activation that emerges at this point comprises a neural representation of the newly acquired motor skill. Changes in memories for newly acquired skills occur when learners are not actively engaged in practice. Practice triggers the onset of memory consolidation, but the process continues after practice has ended (A.R. Luft, M.M. Buitrago, 2005). Memory consolidation is thought to occur in two stages (M.P. Walker, 2005): the first stage, *consolidation-based stabilization*, modifies neural representations of motor skills in ways that make memories resistant to interference and forgetting; the second stage, *consolidation-based enhancement*, yields enhancements in motor performance and memory.

Consolidation-based stabilization typically occurs in the wakeful hours immediately following practice. Wake-based consolidation makes memories resistant to interference from competing tasks (e.g., engaging in motor activity nearly identical to practiced tasks) and maintains performance gains achieved during acquisition (S. Fischer et al., 2002; C. Hotermans, et al., 2006; E.M. Robertson, et al., 2004). The process of wake-based consolidation typically lasts up to four to six hours after active practice has ended. If this process is interrupted, performance of newly acquired skills can be impaired and their memories compromised. Current theory suggests that consolidation-based stabilization is characterized by intermittent occurrences of task-related neural activity and by early protein synthesis in the brain (P. Peigneux et al., 2006). Imaging studies have demonstrated that brain activity during skill acquisition is different from patterns of brain activity elicited when skills are recalled after consolidation-based stabilization has occurred, which suggests that the memories for new skills are modified subsequent to active practice. Consolidation-based enhancement depends on the chemical processes of sleep.

Sleep-based consolidation enhances memories for newly acquired skills so that performance is significantly improved when skills are recalled. In other words, sleep enhances simple motor skill performance in the absence of additional practice (T. Brashers- Krug, et al., 1996; R.A. Duke C.M. Davis, 2006; S. Fischer et al., 2002; S. Fischer, et al., 2005; C. Hotermans et al., 2006; A. Karni et al., 1998; M. Korman et al., 2003; K. Kuriyama, et al., 2004; P. Maquet et al., 2003; S.C. Mednick, et al., 2003; E.M. Robertson, et al., 2005; A.L. Simmons, R.A. Duke, 2006). The chemical processes of sleep are thought to “clean up” neural activity that occurs during acquisition; in other words, processes that occur during sleep disengage neural networks that were active during acquisition but are not essential for optimal task performance (J.H. Benington, M.G. Frank, 2003). Once again, it is clear that memories continue to be encoded and modified after practice has ended in ways that enhance performance when skills are recalled. However, our result showing no significant differences between groups in between massed and distributed practice training regarded to receive skill performance challenges the aforementioned explanations. It seems that the data processing pattern in between the rest and sleep periods in children are different by those in the adults. It was reported there is disengagement in neural networks that were active during acquisition but are not essential for optimal task performance during sleep periods in the adults which leads to improve task performance. However, no straight measurements was done about the children and it certainly warranted to be determined in the future studies whether the sleep data processing pattern in the children is similar to adults or not.

Additionally, it is reported that the performance‑enhancing contribution of the different sleep stages seems to depend on the degree of novelty of the motor task, and on a person’s learning history and level of expertise. When a task appears to be completely new and unfamiliar, until the basic task requirements are met by the learner predominantly processes associated to REM sleep are required. Further optimization (i. e. “fine‑tuning”) of the respective task, or acquisition of a skill similar to a previously learned one, do not require REM sleep any more, since the basic movement pattern in question already has been established. Any further improvements instead are linked to stage 2 sleep now, where they are specifically associated with the occurrence of high frequency “sleep spindles” (K.R. Peters, et al., 2007; C.T. Smith, et al., 2004).

Therefore, it seems that probably one reason for non significant differences observed between distributed and massed training upon receive skill learning in 6 years old children, could be explained by executing both type of the training within a day (without night sleep). So, it is speculated that we could be expect different results by distributing training blocks within multiple days (instead of short resting periods). Accordingly, T. Dail (2002), have reported distribution of Golf practice in 4 consecutive days provide better results than massed training in a single day. However, according to less evidences available with regard to the distribution of practice for children (not adults) in multiple days, more conclusive works certainly remained to be done in this area.

Our most interesting finding was that sex had significant effect on the amount of improvements in skill transfer rate (Local classic game score) in between pre to post test. Another interesting finding was that in spite of this fact that training distribution and it's interaction by the sex had not significant effect on skill transfer rate, in the girls the amount of improvements in distributed training was more. However, in the massed training, the boys had showed more improvements. It should be noted that unfortunately no standard test in available to measure the rate of receive skill transfer within real conditions. In this study, we used a local classic game (a modified handball) based on the experts advice. I this game because of real competitive condition, the count of total balls passed to each individual and the situation of receive (dependent on the counterpart's pressure) would not necessarily be the same for every subject which could affect the final results. Therefore, it seems that well controlled studies (by applying the standard or valid tests) should be done in this context. Consequently, this finding suggests that the amount of transfer rate improvement in during distributed or massed training is inclusive for each sex group. However, because we didn't measure the skill transfer rate in acquire phase, it seems that such a data in the future studies could be more beneficial.

In conclusion, based on our results administration of distributed training for receive skill learning in children has no advantage on massed training during acquire or remember phase. Therefore, the massed training likely be preferential according to its less time requirements. Additionally, massed training protocol recommended for the boy against distributed training for the girls to more skill transfer rate to the real game conditions to be accomplished. However, because of less straight evidences available in this area more conclusive studies remained to be done.

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