Sport Sciences and Health Research

EISSN:2981-0205
https://sshr.ut.ac.ir/

The impact of success criteria in high-error practice conditions on motor learning, self-efficacy, and mood states: A challenge to the optimal theory

Samaneh Sadat Khalilirad[1]*, Hasan Mohammadzadeh[1], Farahnaz Ayatizadeh Tafti[2]

1. Department of Motor Behavior and Sports Management, Faculty of Sport Sciences, Urmia University, Urmia, Iran. (*Corresponding author: ss.khalilirad@gmail.com, https://orcid.org/0000-0003-0082-2250)
2. Department of Sport Sciences, Yazd University, Yazd, Iran.

Article Info

Article type:

Original Article

Article history:

Received: 26 January 2024

Revised: 04 April 2024

Accepted: 13 April 2024

Published online: 01 July 2024

Keywords:
high-error practice,
mood states,
optimal theory,
self-efficacy,
success criteria.

Abstract

Background: Identifying the practice conditions that optimize the learning of motor skills is one of the main objectives in the area of human motor learning research.

Aim: The present study aims to explore the effect of success criteria in high-error practice conditions on motor learning, self-efficacy, and mood states among female students.

Materials and Methods: This practical quasi-experimental study was conducted in a field setting. The participants were 30 female students from Yazd University, selected through convenience sampling. Completing the consent form, the selected participants were randomly divided into three groups: high-error practice with a large target (n= 10), high-error practice with a small target (n= 10), and a high-error control group (n= 10). Then, mixed ANOVA was applied in order to test the hypotheses.

Results: The results revealed that both of the large and small target groups significantly outperformed the control group regarding the difference in performance accuracy. Moreover, considering mood states, in the small target group, significant differences were observed in the calmness, happiness, and total mood state subscales, while in the large target group, significant differences were found in the vigor, happiness, depression, and total mood state subscales. In terms of self-efficacy, significant differences were observed in the level and power dimensions in small target group; however, the power dimension was the mere aspect revealing significant difference in the large target group.

Conclusion: The use of success criteria in high-error practice methods is beneficial, and it is recommended to adopt this approach to improve accuracy and stability in the practice sessions.

Cite this article: Khalilirad SS, Mohammadzadeh H, Ayatizadeh Tafti F. "The impact of success criteria in high-error practice conditions on motor learning, self-efficacy, and mood states: A challenge to the optimal theory". *Sport Sciences and Health Research*. 2024; 16(2): 253-265. DOI: https://doi.org/10.22059/sshr.2024.381467.1159.

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EISSN: 2981-0205 | Web site: https://sshr.ut.ac.ir/ | Email: sshr@ut.ac.ir
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1. Introduction

The organization and arrangement of practice for effective learning have always been a valuable area for research and discussion in motor skill acquisition. Consequently, a major objective in the study of human motor learning has been to identify practice methods that optimize motor skill development [1]. Training motor skills have always been one of the primary concerns of sports coaches and physical education teachers. One of their challenges, in this area, is to develop an appropriate approach to teaching and learning motor skills that adequately addresses cognitive, motor, and underlying mechanism needs [2]. Based on traditional motor learning theories, significant conscious engagement is involved in acquiring primary motor skills, where the performer strives to discover effective and efficient movement patterns for skill execution. Such awareness and knowledge are derived from information that learners can verbally describe, leading the performer to acquire a set of explicit rules regarding how to perform the skill. The process of conscious control relies on working memory resources, which are responsible for temporal storage and information manipulation in the mind [3].

Undoubtedly, in the early stages of motor learning, the learner becomes aware of the rules governing the skill and consciously learns it through a process of constructing, testing hypotheses, and developing a set of verbalizable rules. Some refer to this type of learning as explicit learning [4]. Motor learning theorists introduce a high-error practice approach as another beneficial training method for learning. High-error learning conditions provide opportunities for learners to choose the correct movement pattern [5]. This approach may involve encouraging hypothesis-testing behavior regarding movement strategies, increasing problem-solving processes through various experiences, and overcoming mistakes [6].

According to the literature, high-error practice methods have been shown to result in explicit learning (in fact, it can be taken into account as another form of explicit learning). In this method, the learning environment is characterized by a high probability of errors during skill performance (execution).

Consequently, the performer is compelled to test numerous hypotheses to correct errors and mistakes in order to achieve the desired movement. The outcome of these hypothesis tests leads to the accumulation of a substantial amount of declarative knowledge [6].

Numerous psychological variables have already been identified that influence on the success and failure of athletes. Mood states can be considered as one of the most closely examined variables in sports psychology research being. Lane and Terry (2007) defined mood as a set of transient, intrinsic feelings that vary in intensity and duration, typically lasting longer than emotion and not easily distinguishable from it [7].

The literature has demonstrated that mood states affect various aspects such as perception style, interpretation, planning, execution strategies, performance, self-efficacy, decision-making, and even attitudes [8]. The recognition of these effects has led sports psychologists to study the influence of different physical activities on mood states [9].

Another psychological variable that has attracted the attention of the learning specialists is the level of self-efficacy. Bandura (1997), argued that, among the mechanisms of human agency, no factor is more fundamental and pervasive than individuals' beliefs about their self-efficacy in managing their functions. According to him, the self is a collection of cognitive processes and structures related to thought and perception, encompassing both self-reinforcement and self-efficacy aspects [10]. Self-efficacy beliefs reflect individuals' thoughts, feelings, and motivations regarding themselves. These beliefs are the product of a complex process of self-knowledge, relying on the cognitive processing of diverse sources of effective information, which is actively transmitted through abstract, social, and physiological means [10].

One of the instructional methods proposed to improve motor skill learning is increasing learners' expectations for their performance. This approach is supported by the OPTIMAL (Optimizing Performance through Intrinsic Motivation and Attention for Learning) theory [11]. According to this theory of motor learning, providing instructions that promote an external focus of attention, enhancing learners' sense of autonomy, and raising expectations can facilitate motor skill acquisition. The OPTIMAL theory has identified several factors that benefit from increased expectations:

a) Success expectations can enhance positive feelings and self-efficacy.
b) They prepare individuals for better performance.
c) They influence on both working and long-term memory.

Various strategies and interventions have been employed to demonstrate that motor performance and learning can be improved by increasing the success expectations. These interventions include providing relatively easy standards, visual illusions, and providing feedback after good performances [12]. Another manipulation that researchers have employed to enhance learning involves setting goals that are easier to achieve or establishing success criteria that are more attainable [13].

Recent studies on success criteria have yielded mixed results. For instance, Parma et al. (2023), their findings indicated that lowering the success criterion provided no benefits concerning pressure, effort, explicit knowledge accumulation, or conscious processing. These findings challenge the major principles of the OPTIMAL theory and question the efficacy of success criteria for motor learning [14].

In another study by Mousavi et al. (2022), the researchers showed that providing relatively easy success criteria facilitates motor skill acquisition in children [15]. In addition, the research conducted by Bacelar et al. (2022), showed that, on average, increasing learners' expectations significantly affects skill retention [16].

One of the current discussions in the field is the examination of motor skill learning in beginners (amateur learners). Novices in motor skills differ in various aspects, such as body coordination, movement accuracy, and the definite initiation and completion of movements, among others. The correct performance or execution of many motor skills requires learning, and optimal motor performance depends on the learning process [5].

Therefore, the present study was carried out to compare high-error learning with success criteria (easy and difficult) in the execution of motor skills by beginners and to assess its impact on their self-efficacy and mood states. Also, given the significance of self-efficacy as a motivational and influential factor in learning, understanding how success criteria impact this variable can contribute to the enhancement of the learning process. Ultimately, based on previous research on success criteria, it has been shown that techniques enhancing perceived success are beneficial for consolidating movement and learning, although the strength of these effects and the underlying mechanisms remain unclear [17].

Hence, examining the optimization of practice conditions to increase the potential for motor skill learning among students is of research value. On the one hand, the effectiveness of this variable within the OPTIMAL theory supports its consideration. On the other hand, the lack of studies on the impact of this factor on motor learning under high-error practice conditions, as well as developmental differences, particularly in cognitive aspects among female students, motivated the researcher to conduct this study.

In other words, this research can help to clarify the factors that influence on the learning and execution of the motor skills. Also, sports psychologists have always focused on facilitating conditions, learning environments, and athletes' performance to ensure greater success. Researchers hope that the results of this study will not only address existing ambiguities in this area but also provide conditions that promote improved motor performance and learning.

2. Materials and Methods

2.1. Participation

This study is a practical, field-based, quasi-experimental research that was conducted over three sessions: (1) pre-test phase, (2) acquisition and post-test phase, and (3) retention and transfer test phase. The participants were 30 female students from Yazd University, aged between 19 and 22, who were selected through convenience sampling. After completing consent forms, the participants were randomly assigned to three groups: high-error practice with a large target (n=10), high-error practice with a small target (n=10), and a high-error control group (n=10), This sample size is based on past studies [18]. Inclusion criteria included no prior dart skill experience, relative physical and mental health (based on the Goldberg & Williams questionnaire, 1972), normal vision (based on the Snellen test), and right-handedness (based on the subjects' self-reports), Exclusion criteria were lack of willingness to continue participation, potential physical injury, and practicing darts outside of the prescribed protocol.

2.2. Instrument

2.2.1. Dartboard

A standard dartboard was mounted at a height of 1.73 m from the ground. During the practice sessions, participants in the large and small target groups aimed at yellow circular practice targets with radii of 16 and 7 cm, respectively. These paper targets were affixed to the dartboard. Throws that landed outside the yellow targets did not score any points. Therefore, only throws within the yellow target zone were recorded [19].

2.2.2. Bandura's Self-Efficacy Questionnaire

In order to collect data on self-efficacy expectations, Bandura and Adams' (1977) self-efficacy questionnaire was administered [10]. This questionnaire was adapted by Gernigon and Fleurance (2000) for shooting sports and consists of two main indices. The first index includes five levels and asks participants to state their expectations for their future performance. Levels one through five represent the participant's expectation regarding the number of successful shots out of ten, ranging from one, three, five, seven, to nine. The participant marks "Yes" for each level they believe they can achieve until they reach a level, they feel they cannot accomplish. For each "Yes" response, they then rate their confidence in achieving that result on a scale from 10% (not confident) to 100% (completely confident). This index measures the strength of self-efficacy expectations. The total number of "Yes" responses indicates the level of self-efficacy expectations, and the average confidence percentage for these responses represents the strength of self-efficacy expectations for each individual. Gernigon Gernigon and Fleurance (2000) reported the reliability of the questionnaire as 69% for level and 66% for strength [20].

In a study by Mohammadzadeh (2003), the internal consistency of the questionnaire (using Cronbach's alpha) was reported as 79% without considering the questionnaire items, and 78% and 71% for level and strength, respectively. Given the similarity between shooting and dart throwing in the overall nature of the task, the shooting-related terminology were replaced with the terms concerned with hitting the target [21].

2.2.3. Brom's Mood States Questionnaire

Brom's Mood States Questionnaire [7] is used to assess the mood states (both positive and negative) of the participants. It consists of 32 items across six components: vigor (vitality), tension, fatigue, depression, anger, and confusion. Each item is rated on a scale from 0 to 5, where "not at all" corresponds to a score of 0 and "completely" corresponds to a score of 5. The overall score for each component is obtained by averaging the scores of the four items that make up that component. In a study by Farrokhi et al. (2013) involving 32 male and female athletes across various individual and team sports, the factorial validity and reliability of the Persian version of this questionnaire were evaluated. The internal consistency (Cronbach's alpha) for the components was as follows: tension (0.74), vigor (vitality) (0.80), confusion (0.72), fatigue (0.76), happiness (0.77), relaxation (0.78), depression (0.70), anger (0.72), and the overall questionnaire (0.78). The test-retest reliability was also satisfactory: tension (0.90), vigor (vitality) (0.87), confusion (0.84), fatigue (0.89), happiness (0.87), relaxation (0.86), depression (0.88), anger (0.86), and the overall questionnaire (0.88). These results indicated that the Persian version of the 32-item Brom's Mood States Questionnaire is at a satisfactory level of validity and reliability [22].

2.3. Procedure

One week before the training sessions began, a pre-test was administered to assess the participants' baseline performance and to ensure the homogeneity of the groups. Participants stood 3.5 m from the dartboard and threw darts at the target. The average score of 10 throws for each individual was recorded as their pre-test score [23]. Subsequently, all participants completed self-efficacy and mood state questionnaires. Based on the pre-test results, participants were evenly distributed into the three groups. In the first session, all participants were given identical instructions and were taught the dart-throwing skill. During the acquisition phase, each group completed five blocks of 10 trials (totally 50 trials) at different distances (10 throws per distance). After completing 10 trials at a given distance, participants moved on to the next distance. Those in the high-error group started their throws from 1.5 m and gradually moved to 2, 2.5, 3, and 3.5 m. To prevent fatigue, participants were given a one-minute rest between the blocks. During the acquisition phase, participants were instructed to aim for a specific practice target—throwing the dart into the yellow zone (yellow circular targets with radii of 16 and 7 cm). Points were awarded for each throw. Between practice blocks, participants observed their results using a score sheet to enhance their perception of success or failure and to keep them engaged in the practice [19].

At the end of the acquisition phase, a post-test was administered, and the questionnaires were completed. After a week of no practice, participants performed three warm-up throws (not recorded) and then they performed ten throws from a distance of 3.5 m without the yellow practice targets (standard) for the retention test, with the results being recorded. The transfer test was conducted on the same day after a 10 min rest following the retention test. For the transfer test, participants in each group performed ten throws from a distance of 4 m (without the yellow practice targets).

2.4. Statistic

For the statistical analysis, descriptive statistics such as mean and standard deviation were used to summarize the data. Moreover, the inferential statistics were applied to test the research hypotheses. The normality of data distribution was assessed using the Shapiro-Wilk test, and homogeneity of variances was evaluated using Levene's test. Hypotheses were analyzed using mixed ANOVA, and the data were processed with SPSS version 23, with a significance level set at 0.05.

3. Results

Tables 1, 2, and 3 present the descriptive statistics of the studied variables, including the mean and standard deviation for the three groups: small target, large target, and control.

Table 1. Descriptive results on performance accuracy in the small target, large target, and control groups

	Small target	**Large target**	**Control**
Pre-test	20.81 ± 20.31	39.20 ± 21.41	38.90 ± 14.96
Post-test	22.29 ± 10.48	57.70 ± 25.22	45.90 ± 15.67
Retention	53.70 ± 26.65	67.30 ± 21.50	48.60 ± 17.01
Transfer	39.90 ± 17.91	55.90 ± 24.26	43.00 ± 15.95

Table 2. Descriptive results on mood states in the small target, large target, and control groups

	Pre-test			**Post-test**		
	Small target	**Large target**	**Control**	**Large target**	**Small target**	**Control**
Tension	1.90 ± 1.59	2.00 ± 1.41	1.80 ± 1.03	2.40 ± 1.57	1.80 ± 1.54	2.80 ± 1.93
Depression	1.40 ± 1.64	1.20 ± 0.91	1.70 ± 0.82	1.40 ± 1.26	2.50 ± 2.41	2.40 ± 0.96
Anger	1.60 ± 1.35	1.10 ± 1.52	1.80 ± 1.47	2.30 ± 1.63	1.30 ± 1.88	1.70 ± 1.63
Vigor	8.80 ± 2.86	6.60 ± 3.09	8.60 ± 3.65	9.40 ± 2.91	11.00 ± 2.26	7.60 ± 3.37
Fatigue	2.10 ± 1.28	2.30 ± 1.70	2.00 ± 0.66	3.00 ± 2.05	1.90 ± 1.85	2.10 ± 1.37
Confusion	3.00 ± 2.74	2.20 ± 2.61	2.80 ± 1.13	2.20 ± 1.98	3.30 ± 3.00	3.70 ± 1.49
Calmness	6.90 ± 2.42	7.80 ± 1.98	6.70 ± 2.54	9.80 ± 2.20	7.90 ± 3.14	7.00 ± 2.30
Happiness	7.30 ± 2.31	7.50 ± 1.95	8.90 ± 2.88	9.60 ± 1.71	11.00 ± 1.24	8.80 ± 2.20
Total mood states	33.00 ± 3.85	30.70 ± 5.61	34.30 ± 6.78	40.10 ± 7.82	40.40 ± 7.79	36.10±7.90

Table 3. Descriptive results on self-efficacy in the small target, large target, and control groups

	Expectations			**Power**		
	Small target	**Large target**	**Control**	**Small target**	**Large target**	**Control**
Pre-test	2.70 ± 0.67	3.30 ± 0.48	3.00 ± 1.15	60.60 ± 9.61	60.30 ± 8.46	60.00 ± 12.53
Post-test	3.20 ± 0.78	3.50 ± 0.70	3.00 ± 1.05	77.50 ± 13.46	73.00 ± 15.81	61.70 ± 11.11

3.1. Performance accuracy

The results from the 3 (groups: small target, large target, control) × 4 (pre-test, post-test, retention, transfer) mixed analysis of variance revealed the following within-subjects effects: the main effect of time (pre-test, post-test, retention, transfer) was significant (*P*= 0.001, F (3, 25)= 16.11), the main effect of group (small target, large target, control) was not significant (*P*= 0.34; F(2, 27)= 1.10), and the interaction effect between group and time was not significant (*P*= 0.27; F(6, 50)= 1.30). Given the significance of the main effect of time, further analysis was conducted to explore these effects.

Based on the interactive effect results, a significant difference was observed in the small target group (test power= 0.96, partial η2= 0.46, *P*= 0.001, F(3,25)= 7.27) and the large target group (test power= 0.99, partial η2= 0.55, *P*= 0.001, F(3,25)= 10.22), while no significant difference was found in the control group (test power= 0.30, partial η2= 0.13, *P*= 0.29, F(3,25)= 1.31). Based on the effect size values, it can be inferred that approximately 46% of the changes in the small target group and 55% of the changes in the large target group were likely influenced by the use of the high-error method in instruction.

3.2. Mood states

The results obtained from the 3 (small target, large target, control) × 2 (pre-test, post-test) × 9 (tension, depression, anger, vitality, fatigue, confusion, calmness, happiness, overall mood states) mixed analysis of variance revealed the following effects for within-subject factors: the main effect of time (pre-test, post-test; *P*= 0.001, F(1,27)= 22.29), the main effect of groups (small target, large target, control; *P*= 0.86, F(2,27)= 0.14), the main effect of mood states (*P*= 0.001, F(8,20)= 165.07), the interactive effect between group and time (*P*= 0.06, F(2,27)= 3.13), the interactive effect between group and mood states (*P*= 0.72, F(16,42)= 0.75), the interactive effect between time and mood states (*P*= 0.01, F(8,20)= 3.45), and the three-way interaction between time, group, and mood states (*P*= 0.001, F(16,42)= 3.24). Given the significance of the interactive effects, their impacts were further examined.

Based on the results of the interactive effect, no significant differences were observed in the small target group for the dimensions of tension (test power= 0.13, partial η2= 0.02, *P*= 0.39, F(1,27)= 0.73), depression (test power= 0.05, partial η2= 0.001, *P*= 1, F(1,27)= 0.001), anger (test power= 0.21, partial η2= 0.05, *P*= 0.23, F(1,27)= 1.46), vitality (test power= 0.09, partial η2= 0.01, *P*= 0.54, F(1,27) = 0.37), fatigue (test power= 0.34, partial η2= 0.08, *P*= 0.11, F(1,27)= 2.59), and confusion (test power= 0.16, partial η2= 0.03, *P*= 0.32, F(1,27)= 0.99). However, significant differences were observed in the dimensions of calmness (test power= 0.98, partial η2= 0.40, *P*= 0.001, F(1,27)= 18.32), happiness (test power= 0.85, partial η2= 0.26, *P*= 0.004, F(1,27)= 9.68), and overall mood states (test power= 0.85, partial η2= 0.26, *P*= 0.004, F(1,27)= 9.76). Based on the effect size values, it can be inferred that approximately 40% of the changes in calmness, 26% of the changes in happiness, and 26% of the changes in overall mood states were likely influenced by the use of the small target in the high-error practice method.

In the large target group, no significant differences were observed in the dimensions of tension (test power= 0.06, partial η2= 0.004, *P*= 0.73, F(1,27)= 0.11), anger (test power= 0.06, partial η2= 0.004, *P*= 0.73, F(1,27) = 0.11), fatigue (test power= 0.10, partial η2= 0.01, *P*= 0.48, F(1,27)= 0.51), confusion (test power= 0.16, partial η2= 0.03, *P*= 0.32, F(1,27)= 0.99), and calmness (test power= 0.05, partial η2= 0.001, *P*= 0.88, F(1,27)= 0.02).

Table 4. Pairwise comparisons of groups across pre-test, post-test, retention, and transfer

		Small target			Large target			Control		
Time (i)	**Time (j)**	**Mean difference**	**Standard deviation**	**P value (sig)**	**Mean difference**	**Standard deviation**	**P value (sig)**	**Mean difference**	**Standard deviation**	**P value (sig)**
Pre-test	Post-test	16.90	4.39	0.001*	18.50	4.39	0.001*	7.00	4.39	0.12
Pre-test	Retention	22.50	4.96	0.001*	28.10	4.96	0.001*	9.70	4.96	0.06
Pre-test	Transfer	8.70	4.45	0.06	16.70	4.45	0.002*	4.10	4.45	0.36
Post-test	Retention	5.60	2.75	0.05	9.60	2.75	0.002*	2.70	2.75	0.33
Post-test	Transfer	8.20	4.34	0.07	1.80	4.34	0.68	2.90	4.34	0.51
Retention	Transfer	13.80	3.65	0.001*	11.40	3.65	0.004*	5.60	3.65	0.13

*P<0.05

Table 5. Pairwise comparison of groups in pre-test and post-test of mood states

			Small target			Large target			Control		
	Time (i)	**Time (j)**	**Mean difference**	**Standard deviation**	**P value (sig)**	**Mean difference**	**Standard deviation**	**P value (sig)**	**Mean difference**	**Standard deviation**	**P value (sig)**
Tension	Pre-test	Post-test	0.50	0.58	0.39	0.20	0.58	0.73	1.00	0.58	0.09
Depression	Pre-test	Post-test	2.22	0.50	1.00	1.30	0.50	0.01*	0.70	0.50	0.17
Anger	Pre-test	Post-test	0.70	0.57	0.23	0.20	0.57	0.73	0.10	0.57	0.86
Vigor	Pre-test	Post-test	0.60	0.97	0.54	4.40	0.97	*0.001	1.00	0.97	0.31
Fatigue	Pre-test	Post-test	0.90	0.55	0.11	0.40	0.55	0.48	0.10	0.55	0.85
Confusion	Pre-test	Post-test	0.80	0.80	0.32	0.80	0.80	0.32	0.90	0.80	0.27
Calmness	Pre-test	Post-test	90.2	0.67	*0.001	0.10	0.67	0.88	0.30	0.67	0.66
Happiness	Pre-test	Post-test	30.2	0.73	*0.004	3.50	0.73	*0.001	0.10	0.73	0.89
Total mood states	Pre-test	Post-test	7.10	2.27	*0.004	9.70	2.27	*0.001	1.80	2.27	0.43

*P<0.05

Table 6. Pairwise comparison of groups in pre-test and post-test of self-efficacy

			Small target			Large target			Control		
	Time (i)	**Time (j)**	**Mean difference**	**Standard deviation**	**P value (sig)**	**Mean difference**	**Standard deviation**	**P value (sig)**	**Mean difference**	**Standard deviation**	**P value (sig)**
Level	Pre-test	Post-test	0.50	0.19	0.001*	0.20	0.19	0.31	4.44	0.19	1.00
Power	Pre-test	Post-test	16.90	4.84	0.002*	12.70	4.84	0.01*	1.70	4.84	0.72

*P<0.05

However, significant differences were found in the dimensions of depression (test power= 0.70, partial η2= 0.19, *P*= 0.01, F(1,27)= 6.69), vitality (test power= 0.99, partial η2= 0.43, *P*= 0.001, F(1,27)= 20.35), happiness (test power= 0.99, partial η2= 0.45, *P*= 0.001, F(1,27)= 22.42), and overall mood states (test power= 0.98, partial η2= 0.40, *P*= 0.001, F(1,27)= 18.19). It can be inferred that approximately 19% of the changes in depression, 43% of the changes in vigor (vitality), 45% of the changes in happiness, and 40% of the changes in overall mood states were likely influenced by the use of the large target in the high-error practice method.

In the control group, no significant differences were observed in the dimensions of tension (test power= 0.37, partial η2= 0.09, *P*= 0.09, F(1,27)= 2.93), depression (test power= 0.26, partial η2= 0.06, *P*= 0.17, F(1,27)= 1.94), anger (test power= 0.05, partial η2= 0.001, *P*= 0.86, F(1,27)= 0.03), vitality (test power= 0.16, partial η2= 0.03, *P*= 0.31, F(1,27)= 1.05), fatigue (test power= 0.05, partial η2= 0.001, *P*= 0.85, F(1,27)= 0.03), confusion (test power= 0.19, partial η2= 0.04, *P*= 0.27, F(1,27)= 1.25), calmness (test power= 0.07, partial η2= 0.007, *P*= 0.66, F(1,27)= 0.19), happiness (test power= 0.05, partial η2= 0.001, *P*= 0.89, F(1,27)= 0.01), and overall mood states (test power= 0.11, partial η2= 0.02, *P*= 0.43, F(1,27)= 0.62).

3.3. Self-efficacy

The results obtained from the 3 (small target, large target, control) × 2 (pre-test, post-test) × 2 (level and strength) mixed analysis of variance revealed the following effects for within-subject factors: the main effect of time (pre-test, post-test; *P*= 0.001, F(1,27)= 15.001), the main effect of groups (small target, large target, control; *P*= 0.15, F(2,27)= 2.01), the main effect of self-efficacy (*P*= 0.001, F(1,27)= 1355.34), the interactive effect between group and time (*P*= 0.07, F(2,27)= 2.87), the interactive effect between group and self-efficacy (*P*= 0.15, F(2,27)= 2.03), the interactive effect between time and self-efficacy (*P*= 0.001, F(1,27)= 12.88), and the three-way interaction between time, group, and self-efficacy (*P*= 0.11, F(2,27)= 2.39). Given the significance of the interactive effects, their impacts were further examined.

Based on these results, the interactive effect revealed significant differences in the small target group for the dimension of level (test power= 0.70, partial η2= 0.19, *P*= 0.01, F(1,27)= 6.68) and the dimension of strength (test power= 0.92, partial η2= 0.31, *P*= 0.002, F(1,27)= 12.18). These effect size values suggest that approximately 19% of the changes in the level dimension and 31% of the changes in the strength dimension in the small target group were likely influenced by the use of the high-error teaching method. In the large target group, no significant difference was observed in the level dimension (test power= 0.16, partial η2= 0.03, *P*= 0.31, F(1,27)= 1.06), but a significant difference was found in the strength dimension (test power= 0.71, partial η2= 0.20, *P*= 0.01, F(1,27)= 6.87). It can be inferred that 20% of the changes in the strength dimension in the large target group were likely influenced by the use of the high-error teaching method. In the control group, no significant differences were observed in either the level dimension (test power= 0.05, partial η2= 0.001, *P*= 1, F(1,27)= 0.001) or the strength dimension (test power= 0.06, partial η2= 0.005, *P*= 0.72, F(1,27)= 0.12).

4. Discussion

The present study was conducted to examine the effect of success criteria in high-error practice conditions on motor learning, self-efficacy, and mood states. The results revealed that performance accuracy showed significant differences in both the small target and large target groups, with approximately 46% of the variance in the small target group and 55% of the variance in the large target group being influenced by the high-error training method. However, in the control group, no significant performance was observed.

Considering mood states, significant differences were observed in the small target group for the subscales of relaxation, happiness, and overall mood states, while in the large target group, significant differences were found in the subscales of depression, vigor, happiness, and overall mood states. No significant differences were observed for the remaining subscales. In terms of self-efficacy, the small target group revealed significant differences in both the level and strength dimensions, whereas the large target group showed significant differences only in the strength dimension, with no significant difference in the level dimension. Where significant differences were observed, they were influenced by the use of the high-error training method. The findings of this study are consistent with those of Ong et al. (2015) [19], Mousavi et al. (2020) [15], Bacelar et al. (2022) [16], Ong and Hodge (2018) [24], and Wulf et al. (2013) [25]. However, they are inconsistent with the research conducted by Azmi et al. (2020) [26], Maxwell et al. (2017) [27], Ong et al. (2019) [28], and Parma et al. (2023) [14].

Ong et al. (2015) revealed that the group with a large target achieved more successes and reported greater self-confidence (or self-efficacy) compared to the group with a small target [19].

Mousavi et al. (2020) found that providing relatively easy criteria facilitated the acquisition of motor skills in children [15].

Bacelar et al. (2022) used a meta-analytical approach to estimate the average and individual effect sizes of six types of manipulations to increase expectations. Their results showed that, on average, increasing learners' expectations had a significant effect on skill retention [16].

In a different study, Ong and Hodge (2018) found that while manipulations affected competence and arousal, they did not impact balance outcomes. This data contrasts with the claims of the OPTIMAL theory, which posits that perceived success moderates motor learning [24].

Finally, Wulf et al. (2013) indicated that expected success likely leads to greater success and helps consolidate memories [25].

In studies with divergent results, Azmi et al. (2020) concluded that errorless learning is more effective for dart throwing skill acquisition compared to errorful learning. They found that errorless learning reduces errors and cognitive demands during task performance, resulting in a stable environment and consistent motor patterns [26].

Maxwell et al. (2017) found that errorless learning leads to more stable and consistent motor performance [27]. Additionally, Ong et al. (2019) revealed that participants throwing darts at a large target had higher expectations of success compared to those throwing at a small target. However, participants in the large target group did not exhibit better acquisition performance than those in the small target group [28].

Finally, Parma et al. (2023) indicated that reducing the success criterion does not benefit pressure, effort, explicit knowledge accumulation, or conscious processing [14].

These findings challenge key principles of the OPTIMAL theory and question the efficacy of success criteria for motor learning. Possible reasons for the discrepancies between the current study and the mentioned research include differences in physical activity types, training protocols, participant gender, age range, duration of training, and the number of training sessions during the acquisition phase.

5. Conclusions

As a result, according to the OPTIMAL theory, conditions that foster high performance expectations prepare individuals for successful performance at various levels (e.g., motivational, cognitive, neuromuscular, and neurophysiological) [11]. According to Wulf's (2013) Optimal Theory, behaviors that improve the perception of success increase motivation for repeating desired actions in the future. A training environment that minimizes errors boosts self-efficacy, autonomy, and performance expectations, thus facilitating learning and reinforcing perception and action [25].

Therefore, this study demonstrated that the use of error-based instructional methods can have positive effects on motor skill learning and psychological variables. The results indicate that, in high-error training conditions, considering success criteria especially among novice individuals can lead to improvements in performance accuracy. Specifically, these methods allow learners to gain a better understanding of movements and proper techniques through engagement with challenges and errors. Additionally, the findings revealed an increase in self-efficacy among learners. This enhancement in self-efficacy can act as a significant motivational factor in the learning process, encouraging learners to persist in their efforts and improve their performance. Furthermore, the positive impact on mood states, including increased relaxation and happiness in target groups, underscores the importance of addressing psychological aspects in the learning process. These results can assist coaches and sports professionals in designing more effective educational strategies that not only emphasize the improvement of motor skills but also consider the psychological and emotional growth of learners. Specifically, developing training programs that appropriately incorporate success criteria can enhance performance and motor learning in novice individuals. Finally, this study highlights the necessity for further research in this area to gain a deeper understanding of the effects of error-based instructional methods on motor learning and psychological variables. In this way, we can develop better strategies for enhancing learning and performance in various sports contexts.

6. Study limitations

Limitations of the present study include various factors such as participants' rest periods throughout the day, psychological factors like stress and anxiety during testing, genetic effects, and individual differences in response to training. Future research should examine the effects of other activities that might influence on performance and consider longer training durations and more frequent sessions per week. Additionally, future studies should explore the impact of gender on the current research variables and compare the results accordingly.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc. This study was approved by the Ethics Committee of Yazd University (Ethics Code: IR.YAZD.REC.1403.062). All participants have signed informed consent prior to enrolment in the study. This research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Acknowledgment

The authors of this study would like to express their sincere gratitude to all the individuals who participated in the research.

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