

Different Interactive Feedback of Virtual Partners on Sports Motivation

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Abstract. In the post-epidemic era, virtual partners have become good helpers in home fitness. Previous studies have shown that different interactive feedback from virtual partners will have different effects on individual sports incentives, among which sports incentives objectively include the improvement of sports ability. In this research, the virtual partner's exercise companion experiment was carried out, and the exercise oxygen uptake was taken as the dependent variable, and the factorial experiment was carried out in 3 x 2 (with or without positive encouragement feedback), in which the positive encouragement feedback included goal-oriented encouragement and non-goal-oriented encouragement. It is found that both moderate negative feedback and positive encouraging feedback of virtual partners can improve individual exercise oxygen uptake, and moderate negative feedback is more effective.

Keywords: virtual partner; sports motivation; interactive feedback.

1. Introduction

According to China's "2022 National Fitness Trend Report", the proportion of people aged 7 and above who participate in physical exercise at least once a week is 67.5%, an increase of 18.5% compared with the 2014 survey. Home fitness has become a new sports fitness scene, and at the same time, it has produced more diverse forms of exercise. Among them, somatosensory fitness games with virtual partners were deeply loved by everyone during the epidemic, such as Nintendo's fitness ring adventure and full dance. A lot of research and experiments have proved that interacting with computers under anthropomorphic conditions is regarded as a social behavior, and people's reaction to computers is similar to that when facing real people[1, 2].

Compared with the research on real sports partners, the research on the influence of virtual partners' interactive feedback on sports incentive effect is relatively lacking[3]. This research intends to explore what kind of interactive feedback form of virtual partners is more conducive to sports motivation, and this research can provide some reference value for the design and application of virtual partners in sports.

2. Research method

2.1 Experimental subject

The experiment screened the subjects through the following conditions: (1) The subjects have not received the guidance of scientific sports fitness theory and practice methods; (2) The subjects are healthy and have no history of cardiovascular and respiratory diseases. A total of 15 male college students participated in this virtual partner exercise companion experiment.

2.2 Experimental independent variable

2.2.1 Positive encouraging feedback from virtual partners

Positive encouragement feedback of virtual sports partners mainly includes goal-oriented encouragement and non-goal-oriented encouragement, which are two different strategies used to motivate and guide users to exercise in virtual sports environment[4, 5]. Among them, goal-oriented

encouragement refers to emphasizing specific goals or achievements when motivating users. Non-goal-oriented encouragement refers to encouraging users to participate in sports through positive language and emotions without emphasizing specific goals when motivating users[5].

2.2.2 Moderate negative feedback of virtual sports partners

Moderate negative feedback mainly focuses on the difference between users' current performance and expected standards, and puts forward constructive feedback to help users understand and improve[6]. There are five characteristics: (1)negative feedback is aimed at the task itself rather than the performance of others;(2) Negative feedback is attributed to personal efforts rather than personal abilities; (3) expressing negative feedback in a mild tone rather than in a harsh tone;(4)It is necessary to add encouragement or reward to criticism;(5) Negative feedback supports autonomy rather than control.

2.3 Experimental Method

This experiment is a 3 (no encouragement, goal-oriented encouragement and non-goal-oriented encouragement) \times 2 (with or without moderate negative feedback) factorial experiment design. The content of this experiment is to perform a series of sports actions with virtual sports partners in the big screen according to their voice instructions[7]. By collecting subjective and objective data of subjects through experiments, combining with experimental data analysis and interviews, this paper explores the influence of different feedback interaction modes of virtual sports partners on individual sports level. The details are shown in the following table.

Table 1. Combination of different interactive feedback forms of virtual partners

Numble	Independent variable
1	No positive encouragement and no moderate negative feedback
2	No positive encouragement and moderate negative feedback
3	Have goal-oriented encouragement and no moderate negative feedback.
4	Have goal-oriented encouragement and moderate negative feedback.
5	Have non-goal-oriented encouragement and no moderate negative feedback.
6	Have non-goal-oriented encouragement and moderate negative feedback.

2.4 Experimental device

2.3.1 MP150 telemetry physiological recorder

In this research, MP150 physiological signal telemetry recording system developed by BIOPAC Company in the United States was used to collect physiological data information of surface EMG signals. Among them, the experimental design mainly considers rectus femoris (REC), a muscle that plays a central role in sports activities, as the focus of this research.



a.股直肌 (REC)

Fig. 1 EMG signal acquisition

2.3.2 Exercise heart rate armband

Polar Verity Sense is a professional sports heart rate monitoring armband, which is widely used by athletes and fitness enthusiasts to monitor and analyze heart rate data in various sports activities,

and has made remarkable achievements in athlete selection, sports training and exercise load adjustment[8].



Fig. 2 Polar Verity Sense

In this experiment, Polar Verity Sense exercise heart rate armband is used to obtain objective physiological data such as actual heart rate, average heart rate, maximum heart rate, minimum heart rate and energy consumption (kcal)[9].

2.5 Data calculation method

2.4.1 EMG signal

In this experiment, the MF mean difference of rectus femoris muscle during static isometric contraction under the load of lifting 10% of its own weight before and after the experiment will be collected to evaluate muscle exercise fatigue.

$$\Delta MF = \frac{1}{2} \int_{N3}^{N4} PSD(f) df - \frac{1}{2} \int_{N1}^{N2} PSD(f) df$$

2.4.2 Heart rate data

By using Polar Verity Sense heart rate monitoring equipment, the heart rate data are recorded during aerobic exercise between subjects and virtual exercise partners. In this experiment, HR_{index} will be used to estimate the oxygen uptake (VO_2) of subjects during exercise[10,11].

$$HR_{index} = HR_{actual} / HR_{resting}$$

$$METs = (HR_{index} \times 6) - 5$$

$$VO_2 = METs \times 3.5$$

3. Research results

3.1 Exercise oxygen uptake results

The average value of oxygen intake of subjects under different forms of interactive feedback of virtual partners is shown in the following table.

Table 2. Average value of oxygen intake of subjects under different forms of interactive feedback from virtual partners

Characteristics of interactive feedback form of virtual partners		VO_2 (ml/kg)	SD
No moderate negative feedback	No encouragement	82.94	7.01
	Goal-oriented encouragement	85.63	6.97
	Non-goal-oriented encouragement	94.40	7.22
Have Moderate negative feedback	No encouragement	90.74	5.64
	Goal-oriented encouragement	101.12	8.94
	Non-goal-oriented encouragement	99.85	9.28

The average value of exercise oxygen uptake of subjects in different forms of interactive feedback of virtual partners was detected spherically, and the P values were all greater than 0.05, indicating that the data met the spherical hypothesis and there was no need to adjust the degree of freedom. Therefore, the data will be processed by repeated measurement variance analysis, and the analysis results are shown in the following table.

Table 3. Analysis of variance of subjects' oxygen intake under different forms of interactive feedback from virtual partners

Factors	F	<i>p</i>
Positive encouraging feedback	152.89	0.000***
Moderate negative feedback	165.21	0.000***
Positive encouraging feedback * Moderate negative feedback	12.17	0.001**

The main effect of virtual partner's positive encouraging feedback is significant, and the difference between groups with positive encouraging feedback and without positive encouraging feedback is statistically significant ($p=0.000<0.001$). The moderate negative feedback effect of virtual partners is significant, and the difference between groups without moderate negative feedback and with moderate negative feedback is statistically significant ($p=0.000<0.001$).

In addition, the interaction effect between positive encouraging feedback and moderate negative feedback of virtual partners is significant, and a simple effect analysis is needed. According to the hypothesis, it is proposed that the oxygen uptake of the virtual partner may be affected by moderate negative feedback due to the non-goal-oriented encouragement feedback and goal-oriented encouragement feedback, so a simple effect analysis is carried out, as shown in the following table.

Table 4. The T of subjective effect of non-goal-oriented encouragement on predicted oxygen uptake with or without moderate negative feedback

Fixed condition	Factors	F	<i>p</i>
No moderate negative feedback	With or without non-goal-oriented encouraging feedback	20.42	0.000***
Have Moderate negative feedback	With or without non-goal-oriented encouraging feedback	1.85	0.181

From the above table, it can be seen that the non-goal-oriented encouragement feedback has a significant main effect without moderate negative feedback, $p=0.000$, indicating that the non-goal-oriented encouragement of virtual partners can significantly improve individual exercise oxygen uptake; Under the condition of moderate negative feedback, the main effect of non-goal-oriented encouragement feedback is not significant, $p=0.181$, which indicates that the non-goal-oriented encouragement feedback of virtual partners can not significantly improve the individual exercise oxygen uptake.

Table 5. The T of subjective effect of goal-oriented encouragement on predicted oxygen uptake with or without moderate negative feedback

Fixed condition	Factors	F	<i>p</i>
No moderate negative feedback	With or without non-goal-oriented encouraging feedback	20.42	0.000***
Have Moderate negative feedback	With or without non-goal-oriented encouraging feedback	1.85	0.181

From the above table, it can be seen that the main effect of goal-oriented encouragement feedback is not significant without moderate negative feedback, $p=0.263$, which shows that the goal-oriented encouragement of virtual partners can not significantly improve individual exercise oxygen uptake; Under the condition of moderate negative feedback, the goal-oriented encouragement feedback effect is significant, $p=0.044$, which shows that the goal-oriented

encouragement feedback of virtual partners can significantly improve the individual exercise oxygen uptake.

3.2 MF difference before and after rectus femoris exercise

In addition, this research will also collect the changes of the average MF of rectus femoris under different forms of interactive feedback from virtual partners.

Table 6. Mean value difference of MF before and after exercise of rectus femoris

Characteristics of interactive feedback form of virtual partners		MF mean difference(Hz)	SD
No moderate negative feedback	No encouragement	82.94	7.01
	Goal-oriented encouragement	85.63	6.97
	Non-goal-oriented encouragement	94.40	7.22
Have Moderate negative feedback	No encouragement	90.74	5.64
	Goal-oriented encouragement	101.12	8.94
	Non-goal-oriented encouragement	99.85	9.28

And the correlation between these changes and the exercise oxygen uptake of the subjects.

Table 7. Correlation analysis between MF difference and exercise oxygen uptake

Subjects	1	2	3	4	5	6	7	8
Pearson's r	-0.769	-0.631	-0.897*	-0.926**	-0.885*	-0.729	-0.971**	-0.950**
<i>p</i>	0.074	0.179	0.015	0.008	0.019	0.100	0.001	0.004
Subjects	9	10	11	12	13	14	15	
Pearson's r	-0.900*	/	-0.963**	-0.710	-0.905*	/	-0.827*	
<i>p</i>	0.014	/	0.002	0.114	0.013	/	0.042	

From the above table, it can be seen that there is a significant correlation between the MF difference of rectus femoris muscle and exercise oxygen uptake before and after exercise of subjects No.3, 4, 5, 7, 8, 9, 11, 13 and 15; There is a marginal significant correlation between MF difference of rectus femoris muscle and exercise oxygen uptake before and after exercise in No.1 subject. However, there was no significant correlation between the cumulative value of iEMG of rectus femoris muscle and exercise oxygen uptake before and after exercise in subjects No.2, No.6 and No.12, $p>0.05$.

4. Discuss

Through the experiment of whether the virtual partner has moderate negative feedback variable on individual exercise oxygen uptake, it can be concluded that moderate negative feedback with virtual partner can significantly improve the exercise oxygen uptake of the subjects, and the improvement effect is about 11.2%.

Through the experiment of whether the virtual partner has positive encouragement feedback variable on individual exercise oxygen uptake, it can be concluded that the positive encouragement feedback of virtual partner can significantly improve the exercise oxygen uptake of the subjects, and the improvement effect is about 9.6%.

In addition, the goal-oriented encouragement feedback with virtual partner can significantly improve the exercise oxygen uptake of the subjects, and the improvement effect is about 7.3%.the virtual partner's non-goal-oriented encouragement feedback can significantly improve the exercise oxygen uptake of the subjects, and the improvement effect is about 10.7%.

To sum up, it can be concluded that in the univariate situation, the non-goal-oriented encouragement of virtual partners is more helpful to improve the individual's exercise oxygen uptake than the goal-oriented encouragement, indicating that the individual's exercise persistence is higher under the non-goal-oriented encouragement.

At the same time, through the analysis of MF difference before and after exercise, it shows that there is a significant correlation between MF difference of rectus femoris and exercise oxygen uptake before and after exercise in most subjects, and there is no significant correlation between MF difference of rectus femoris and exercise oxygen uptake in a few subjects before and after exercise.

5. Summary

Through experimental research, it is found that the individual's sports motivation will be influenced by different interactive feedback from virtual partners. That is to say, different interactive feedback (moderate negative feedback and positive encouraging feedback) of virtual partners will enhance the individual's sports incentive effect. Among them, the non-goal-oriented encouragement in positive encouragement feedback is more helpful to improve the individual's exercise oxygen uptake than the goal-oriented encouragement.

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