

Effects of different frequencies of rhythmic auditory cueing on the stride length, cadence, and gait speed in healthy young females

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Abstract. [Purpose] The aim of this study was to explore the effects of different frequencies of rhythmic auditory cueing (RAC) on stride length, cadence, and gait speed in healthy young females. The findings of this study might be used as clinical guidance of physical therapy for choosing the suitable frequency of RAC. [Subjects] Thirteen healthy young females were recruited in this study. [Methods] Ten meters walking tests were measured in all subjects under 4 conditions with each repeated 3 times and a 3-min seated rest period between repetitions. Subjects first walked as usual and then were asked to listen carefully to the rhythm of a metronome and walk with 3 kinds of RAC (90%, 100%, and 110% of the mean cadence). The three frequencies (90%, 100%, and 110%) of RAC were randomly assigned. Gait speed, stride length, and cadence were calculated, and a statistical analysis was performed using the SPSS (version 17.0) computer package. [Results] The gait speed and cadence of 90% RAC walking showed significant decreases compared with normal walking and 100% and 110% RAC walking. The stride length, cadence, and gait speed of 110% RAC walking showed significant increases compared with normal walking and 90% and 100% RAC walking. [Conclusion] Our results showed that 110% RAC was the best of the 3 cueing frequencies for improvement of stride length, cadence, and gait speed in healthy young females.

Key words: Rhythmic auditory cueing, Frequency, Gait speed

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INTRODUCTION

Walking is one of the most basic movements of human beings. Detecting the gait parameters of human beings while walking have an important significance for evaluating the recovery of motor function as well as guiding the rehabilitation treatment of clinical patients. The gait speed, which is simple, sensitive, and reliable, is a commonly used index for evaluating walking ability. In addition, cadence and stride length are two important elements of gait speed, which complement each other and are correlated¹).

The gait of the elderly is unstable, and their walking rhythm is disordered. Gait speed and stride length decrease significantly, and the fall risk increases. Parkinson patients have an abnormal posture and gait pattern, which are characterized by decreased stride length, reduced gait speed, and rhythm disorders. As for stroke patients, gait speed, stride length, cadence, and single support duration are also

decreased, while the double support duration is increased. Gait rhythm perturbations are present in both the elderly and people with Parkinson disease (PD) and stroke. In order to solve the abovementioned problems, rhythmic cueing currently has achieved great progress in Parkinson and stroke treatment²). Moreover, rhythmic cueing is receiving much more attention with respect to improvement of walking ability in the elderly and fall prevention³).

Rhythmic cueing is divided into 3 categories, namely, auditory, visual, and somatosensory cues. Auditory rhythmic cueing is mostly chosen in walking treatment, with the cues produced by a metronome⁴).

Previous reports indicate that the use of acoustic rhythms is a more effective method of practice in stroke patients gait rehabilitation⁵). In addition, the gait parameters and synchronization of adults with severe traumatic brain injury were improved with 100% rhythmic auditory cueing (RAC) and 110% RAC; gait speed, stride length, and cadence all increased⁶). Subsequently, in the presence of auditory rhythmic cues, stride length, cadence, and gait speed increased in patients with PD⁷).

Although sufficient evidence has been found to support that auditory rhythmic cueing can improve walking ability in previous literature, there is lack of basic research and a uniform standard for the RAC frequency, and there are many controversies concerning the most suitable frequency for the

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auditory rhythm. Different frequencies of RAC were used in different studies, and the gait parameters changed differently. Further research should be conducted to study the influence of different auditory rhythms on gait.

Therefore, this paper explores the stride length, cadence, and gait speed with rhythmic auditory cueing using three commonly used frequencies (namely, 90%, 100%, and 110%) in healthy young females by using the RAC as a stimulus. The purpose of the study was as preliminary research for figuring out which frequency of RAC is the best for improvement of gait parameters as well as to offer clinical guidance of physical therapy for choosing the suitable frequency of RAC.

SUBJECTS AND METHODS

The subjects were 13 young people (females). The subjects' characteristics are detailed in Table 1.

The purpose and content of this research were explained to the subjects, and all subjects gave their informed consent to participation in the study. The IRB approval number was 2014-5, and the study was approved by the Research Ethics Committee of Capital Medical University.

The tools used in the experiment included a 10 m tape, stopwatch, colored adhesive tapes, and a metronome.

For the study environment, we prepared a clean and quiet environment with a suitable temperature and a cement floor. Walking test points were marked along a flat 16-m distance in a straight line, a start point, 3 m point, 13 m point, and end point with colored adhesive tapes.

In each test, the subjects were asked to walk a total of 16 m. To eliminate acceleration and deceleration effects, only the middle 10 m distance was used for calculations. Firstly, subjects walked as usual 3 times with 3 minutes of seated rest between repetitions. Then, the subjects' mean cadences of normal walking were calculated and then converted to 90%, 100%, and 110% of the mean cadence. The three kinds of RAC (90%, 100%, and 110%) were randomly assigned. Then subjects were asked to listen carefully to the

rhythm of the metronome and walked three times with 3 minutes of seated rest between repetitions. The metronome could be heard clearly by young females and was not thought to be too noisy. Gait speed, stride length, and cadence were calculated.

In order to determine the main effect of the 3 intervention methods, one-way analysis of variance with Bonferroni correction was used; the factor was the walking condition. The data were analyzed by using SPSS Ver. 17.0 of Windows.

RESULTS

The results for stride length, cadence, and gait speed under four conditions (normal walking and 90%, 100%, and 110% RAC walking) are shown in Table 2.

The differences in gait speed and stride length with the auditory rhythm at the different frequencies showed obvious statistical significance. The 100% RAC showed no significant difference in gait speed under the normal walking conditions. The results also showed that the gait speed and cadence for 90% RAC walking showed a significant decrease compared with normal walking and 100% and 110% RAC walking. The stride length, cadence, and gait speed of 110% RAC walking showed significant increases compared with normal walking and 90% and 100% RAC walking. Comparison of normal walking with 100% RAC walking revealed no significant variation.

DISCUSSION

Under the three frequencies of RAC, stride length, cadence, and gait speed showed different changes, with the stride length, cadence, and gait speed during 110% RAC walking all showing significant increases. Therefore, the 110% RAC was the best cueing frequency among the 3 frequencies used to improve the stride length, cadence, and gait speed in healthy young females.

Under higher rhythmic auditory cueing, the strength of the nerve impulse issued by the central motor and the accuracy increase. Therefore, the regulation of skeletal muscle by the central nervous system can strengthen the coordination between the agonistic muscle and antagonistic muscle. When the agonistic muscle is contracting, the antagonistic muscle will fully relax, which can greatly reduce the internal resistance, increase the lower limb joint movement amplitude, and improve the switching frequency of the lower limb. Furthermore, some studies indicate that the RAC can increase the excitability of the spinal motor neurons via

Table 1. Subject characteristics

	Mean±SD (N=13)
Age (y)	21.8±0.4
Height (m)	1.6±0.1
Weight (kg)	53.9±5.6
BMI (kg/m ²)	20.2±1.5

Table 2. Stride length, cadence, and gait speed under four conditions

	Gait parameters under four conditions (Mean±SD)					
	Stride length (m)		Cadence (steps/min)		Gait speed (m/s)	
a. Normal walking	0.98±0.08	a<d*	121.58±6.74	a>b** a<d**	1.47±0.18	a>b** a<d**
b. 90% RAC	0.94±0.07	b<c*.d**	110.18±6.07	b<c.d**	1.28±0.18	b<c.d**
c. 100% RAC	0.98±0.07	c<d**	121.25±6.25	c<d**	1.46±0.17	c<d**
d. 110% RAC	1.02±0.07		133.62±7.54		1.68±0.17	

SD standard deviation (*p<0.05, **p<0.01)

the reticulospinal tract and reduce the muscle reaction time in response to motor commands so as to improve the gait speed⁸). Therefore, 110% RAC can result in a significant increase in stride length, cadence, and gait speed.

In a future study, apart from RAC walking training, rhythmic auditory cueing can be applied to the training of robot-assisted walking, for example ManBuzhe (Tian Jin) Rehabilitation Equipemnt Co., Ltd., in stroke patients, spinal cord injury patients, and even orthopedic disorders patients. It is expected that it can play an active role in weight support and auxiliary active treatment through rhythmic auditory cueing.

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