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Assessment of psychomotor skills using finger pulse guided biofeedback tool in young medical students

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Abstract

Psychomotor skills are the organized patterns of muscular activities guided by signals from the environment. These skills can be influenced by factors like age, gender, built of an individual and handedness. It's a known fact that the dominant hand has more dexterity; nevertheless, proficiency of the non-dominant hand can be improved with repetition of tasks and procedures. The aim of the present study was to examine the influence of biofeedback mechanism on psychomotor skills performance and gender variation in their activity. Eighty participants aged between 20-30 years were recruited after taking the informed consent. All the subjects performed number countdown test and 100 pin dexterity test. Tests were done by fixing the subject's heart beats instead of stipulated time which was picked up by finger Pulse plethysmography using optocoupler principle. The results were compared between the males and age-matched female participants. The pin dexterity scores with a right and left hands in males (57.2±8.1, 42.16±7.3) were significantly higher than females (48.41±8.4, 37.58±6.8) (p = 0.001 and p = 0.01). There was no significant difference in number countdown test scores. The results suggest that males handle a skilled performance better than females. This is perhaps males were less anxious as the task was designed in such way that it has to be completed by counting down the heart beats. In that way, the males got more time duration as the heart rate did not shoot up when the task was assigned.

Introduction

Skill is a reliable link between perception of body and environment, and execution of motor activity, which is consistent across repeated performances and can be flexibly adapted to changes in task constraints **[1]**. So skill primarily considered as a perceptual motor function. Psychomotor skills are wide range of actions that involves physical actions associated with cognitive processing which can be measured in terms of speed and time **[2]**. Thus they can be categorized as simple and complex tasks. Mental and physical capacities are involved in the execution, which requires concentration and attention in the early stages processing **[3]**.

Learning of psychomotor skills involves three phases. Initial 'cognitive phase' during which an individual focus on understanding how to execute the targeted skill and over time knowledge is

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accumulated through trial and error method. Therefore, the initial trials must always demand good deal of attention, feedback and reinforcement since errors are common. This phase is followed by 'associative phase' which is fundamentally a practical phase. This phase involves pure and hard training during which gesture/movement is mastered. When associative phase gone through a rigorous practice individual learns to implement the skill at the highest level of precision and unconsciously which is termed as automatic phase **[4]**.

Thus improvement from the initial cognitive phase through the association and to the unconscious performance of the skill requires accumulation of practice and time depending on the skills of the subject, the learning situation and the complexity of the task **[5]**. However, these skills can be accelerated by biofeedback technique which helps to change the visceral responses that supports to improve psychomotor skills. Biofeedback is a technique learned by an individual to control his/her visceral or internal physiological actions with the help of feedback **[6]**. This is a type of operant conditioning which helps to focus on making subtle changes in the body such as relaxing certain muscles, reducing pain and heart rate. Biofeedback gives control to improve physical performance. There are different types of biofeedback tools which are available that possess a sensor which detects particular parameter and provides feedback to the subject through audio-visual display. So the present study was aimed to assess psychomotor skills and to find out gender variation in medical students using heartbeat count as biofeedback mechanism.

Materials and methods

It was a cross-sectional study where 80 young medical students (40 males, 40 females), aged between 20-30 years were recruited after obtaining written informed consent. This study commenced after getting ethical clearance from Institutional Ethics Committee of Narayana Medical College, Nellore, Andhra Pradesh. All procedures were done in physiology department at Narayana Medical College after light breakfast in the morning. All the methods were clearly explained to the participants before performance of below-mentioned tests.

Anthropometric measurements

Anthropometric measurements such as height by stadiometer, weight by electronic weigh machine were assessed. BMI was calculated by dividing body weight (in kg) by height (in meters) squared.

$$BMI = \frac{Weight}{Height^2}$$

Finger pulse plethysmography

Custom made finger pulse recording tool connected to subject to detect and transmits pulse to recording device. These pulse signals were counted automatically using optocoupler and displayed on the screen as heartbeat count. The display of heartbeat countdown was done using mobile click counter application. This pulse transmission, interphase to count down application was validated by manual comparison of radial and carotid pulse. Psychomotor tasks such as 100 pin dexterity and number countdown test are routinely performed within a stipulated time. Instead in this protocol subject were asked to perform the task within 200 and 100 heartbeats as counting down of heartbeats.

100 pin dexterity test

This test assesses the number of pins placed in the module. The subjects were instructed to place the pins and their score was counted based on their number of pins assembled with 200 heartbeats countdown **[7]**.

Number countdown test

The subjects were instructed to pronounce the numbers in ascending and descending manner with a difference of 2 (0-200) and (200-0) within subject's 100 heartbeats.

Statistical analysis

Statistical analysis was carried out using graphpad prism and data was presented as mean and SD. Normality of data was tested using Kolmogorov-Smirnov test. A p value of > 0.05 indicated normal Gaussian distribution. As the data sets were skewed, Mann-Whitney test was performed and Spearman correlation was done to find out associations.

Results

Right-hand pin dexterity score of in males (57.2 ± 8.1) was significantly greater (p < 0.001) than females (48.41 ± 8.4). Similarly left-hand pin dexterity score of males 42.16 ± 7.3 was also significantly greater than females 37.58 ± 6.8 (p < 0.01). Number countdown test scores were not significant between the groups. However, there was a trend toward higher scores in females 79.65 ± 18 (ascending), 62.93 ± 13.7.8 (descending) than 76.03 ± 12.9, 61.33 ± 10 males (**Table 1**).

The pin dexterity scores between right and left hands revealed significantly higher dexterity with right hand (57.2 ± 8.1) than left-hand score (42.16 ± 7.3) in males (p < 0.001). Similarly, significantly higher right-hand pin dexterity scores (48.41 ± 8.4) were found compared to left hand (37.58 ± 6.8) in females (p < 0.001) (**Table 2**).

Table 1: Pin dexterity and number countdown test scores

Parameters		Males	Females	p-value
Pin dexterity	Right hand	57.2 ± 8.1	48.41 ± 8.4	< 0.001
	Left hand	42.16 ± 7.3	37.58 ± 6.8	< 0.01
Number countdown	Ascending	76.03 ± 12.9	79.65 ± 18.8	0.421
	Descending	61.33 ± 10.0	62.93 ± 13.7	0.466

Table 2: Intragroup comparison of pin dexterity scores between right hand and left hand

Parameter		Right hand	Left hand	p-value
Pin dexterity	Males	57.2 ± 8.1	42.16 ± 7.3	< 0.001
	Females	48.41 ± 8.4	37.58 ± 6.8	< 0.001

Table 3: Intragroup comparison of scores between number ascending and descending test

Parameter		Ascending	Descending	p-value
Number countdown test	Males	76.03 ± 12.9	61.33 ± 10	< 0.001
	Females	79.65 ± 18.8	62.93 ± 13.7	< 0.001

Intragroup comparison of number countdown scores (ascending and descending) revealed that the ascending number count score 76.03 ± 12.9 in males is significantly greater than descending score 61.33 ± 10 (p < 0.001). The same trend shown in females between right 79.65 ± 18.8and left hand 62.93 ± 13.7 score (p < 0.001) (**Table 3**).

Discussion

The aim of the present study was to examine the influence of biofeedback mechanism and gender variation on psychomotor skills performance. We explored above tests by recording the data using heartbeat count of an individual as biofeedback mechanism when they performed the psychomotor tests. The results of current study suggest that there is a significant gender variation in above measured psychomotor skill tests.

The primary goal of this study was to measure psychomotor skills in medical students. We have found significant difference in pin dexterity score between males and females. Subjects were instructed to place as many pins as they can within 200 heart beats. Female subjects were prone to performance anxiety. Though the tasks were time-independent they were heartbeat dependent. As a result, as the hearts beats were counting down female subjects were under pressure, perhaps leading to the increase in the sympathetic drive. This in turn led to faster dropping of heart beat countdown. Therefore, female subjects could place lesser pins than male counterparts as their heartbeats dropped quickly; whereas male subjects were less prone to performance anxiety and sympathetic drive. Therefore, their heart beat countdown was slower compared to females. As a result, male subjects got more time to place more pins. The probable non-significance of number countdown task was due to the familiarity of the numbers was equal in both genders. To the best of our knowledge this is the first study to employ heart beat countdown as feedback while performing the psychomotor tasks.

We have found that there are significant differences in pin dexterity score between right hand and left hand within same individual due to cerebral dominance and regular practice **[8]**. Previous studies have suggested that right-handed males have more innate dexterity than left-handed males **[9]**. However, proficiency with the non-dominant hand can be improved with repetition of tasks and procedures.

We also found the intragroup differences significantly in number countdown test between ascending and descending countdown scores in both groups. These can be explained by the simple perceptual-motor actions can be performed easily when compared to the complex tasks. The pronouncing of numbers in ascending is easy when compared to the descending in order.

Conclusion

Psychomotor skills are the perceptual motor activities which can be quantified by their own heart beat count rather than conventional time dependent measurements. Biofeedback can modulate psychomotor skills by influencing the heartbeat. There is also a significant gender variation in psychomotor skills when assessed through biofeedback mechanism.

Limitations

The present study has some limitations. The subject's initial heart rate was not measured. So the absolute rise in heartbeat could not be calculated. The findings of this study cannot be attributed to long-term skills. Further studies needed to be repeated with same measurements with after familiarization and training effects.

Conflict of interest: None declared

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