EVALUATING NEUROMUSCULAR COORDINATION FOR HANDS AMONG PHYSICAL EDUCATION STUDENTS

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Abstract

The purpose of this study was to evaluate neuromuscular coordination for hands among physical education students. Neuromuscular coordination was evaluated using the soda pop test and the effect of two variables including sex (male and female) and hands (preferred and non-preferred). The data were collected from a sample of (305) students via survey method. Results indicated that sex (male and female) and hands (preferred and non-preferred) appeared most powerful predictors of neuromuscular coordination in favor of female and preferred hand of the student.

Keywords: Neuromuscular coordination, Gender, Handedness, physical education students.

Introduction and theoretical framework

The human body is particularly well suited to perform an infinite number of physical stunts. This performance can provide humans with versatility to produce movements that no machine can even handle. The outstanding and spectacular display of gymnastic and diving routines in the Olympic Games is an obvious display of the uniqueness of the human body as a moving machine.

The ability of the central nervous system to control and manipulate the level and type of muscular activation and/or inhibition of different motor tasks, which requires accuracy and timing, is referred to as coordination. In other words, coordination is the integration of the nervous and the muscular systems to produce correct, graceful, and harmonious body movements in

which hand-eye and/or foot-eye movements, or both, must be integrated (Hoger & Hoger, 2004).

Physiologically speaking, coordination is the ability of the nervous system to select and control the level of degree of freedoms in joint actions; in fact for each degree of freedom in a joint, 4.6 muscle groups are involved in controlling each degree of freedom (Prilutsky & Zatssiorsky, 2002)

Neuromuscular coordination is an important topic that has been variantly discussed in the literature. To elaborate on this issue, the next few paragraphs present the studies that have been in existence related to this topic. For example, Edermann, Mayer, Murray, and Sagendorf, (2004) studied the influence of cup stacking on eye-hand coordination and reaction time of 24 boys and 18 girls in second grade as measured by the soda pop and yardstick tests, respectively. Two physical education classes were randomly assigned as treatment and control groups and were pre- and post-tested for hand-eye coordination and reaction time. The treatment groups participated in a 5-week cup-staking program. Significant improvements were noted for both hand-eye coordination and reaction time between pre- and post-test scores for this group but not for the control group. Therefore, cup staking is indeed effective in enhancing hand-eye coordination and reaction time. It is obvious that the above study focused on fine motor skills for secondary students regardless of the effect of gender. However, Silva, Birkbeck, Russel, and Wilson (1984) compared gross and fine motor skills for 954 secondary male and female students. Results indicated that males out perform females in gross motor tasks while females are superior in fine motor tasks. In short, we can conclude that these studies did not account for the effect of gender with regard to motor and fine skills.

After a thorough perusal of the literature, many investigators (Ardle, Katch, & Katch, 1991; Brook & Fahey, 1984; Bloom & Fitch, 1992; Nieman, 1990; Wells; 1984; Wilmore & Costill,

1991) determined the elements of fitness and physical ability, which was indirectly, relate to gross and fine motor skills. Few of these studies discussed the differences between the sexes. Studies in the area of sex differences in athletic performance witnessed increased momentum when many socio-psychological barriers contributing to female reluctance to sport participation were eliminated in the west. According to these studies in the area of sex difference in performance of the same competitive sport, conclusions were reached among professional coaches working with both sexes (Ardle, Katch & katch, 1991; Brook & Fahey, 1984; Bloom & Fitch, 1992; Nieman, 1990; Wells, 1984; Wilmore & Costill, 1991). These conclusions state that comparison between both sexes in competitive sport must take into account four major differences between the two sexes. These four dimensions include: a) anatomical dimension; b) muscle mass; c) metabolic potential; and d) sex-hormones.

When these four dimensions are taken into account in sport performance, researchers (Brook & Fahey, 1984; Nieman, 1990; Wells, 1984) indicated that the sport performance differences are relative to the type of the fitness elements required for those particular athletic events as follows:

1. Female athlete's performance in strength–dependant sport activities is less than male athletes due to less body mass in females compared to males with the male hormone testosterone as a major contributor to increased muscle mass in male athletes. Accordingly female's performance in strength and power type activities like throwing, leaping and jumping is less compared to males subjected to the same training program.
2. Males have the following advantages in speed dependent activities:
    - Longer lower extremities which give males a mechanical advantage in stride length because longer legs are longer levers.

- More muscle mass in the legs.
- Less fat mass, (this means less inert tissue).

3. Sex differences in short distance races such as 100 and 200-meter dash events are very minimal but increase linearly with increased race distance.
4. In endurance sports, female performance is less than males because males have an advantage in many factors that contribute to oxygen availability and delivery to working muscles such as increased lung size (increased vital capacity), Better maximum ventilation, larger heart and stork volume, increased hemoglobin concentration.
5. Equally trained males will perform better in endurance sports compared to females who never the less, will out perform the untrained age – matched male.

In brief, females are inferior to males in strength and speed dependant athletic events due to anatomical differences between the two sexes (Hales, 1992; Hoger & Hoger, 2004). These factors are behind the almost 10% difference in maximum oxygen uptake in favor of males. However, females can increase their vo2-max through training enough to sustain long distance endurance events such as the marathon.

In spite of this numerous studies there where shortage in the studies which take coordination and its importance and the differences between sexes. An analysis of the research literature on sex differences in simple perceptual-motor tasks has led to conclude that young females exceed their counter males in fine manual dexterity (Broverman, Klaiber, Kobayshi, & Vogel, 1968; Jenson, 2007). Furthermore, females perform better in perceptual motor behaviors associated with speech and reading as well as small muscles simple perceptual motor activities that require speed, repetition and skill. In fact, others (Broverman, Klaiber, Kobayshi, & Vogel, 1968) described motor behaviors in which females are superior to males as behavior with following attributes:

1. The behaviors depend on past experience or learning vs. problem solving of novel or difficult tasks.
2. The behavior involve fine coordination of small muscles with perceptual and observational processes such as typing or reading vs. behavior that call for gross motor activities that involve large muscle groups.
3. The behaviors are evaluated in terms of speed and accuracy of repetitive responses such as color naming vs. behavior that require production of new responses or insight as in maze solutions.

Since the previous literature indicate that most of the research studies were carried out using gross motor activities, the researchers of this study aimed to explore sex-differences in performance of motor tasks that depend on Neuromuscular coordination aspect of motor performance.

Statement of the problem

The need and importance of this study is of value to those investigating neuromuscular coordination. After a thorough perusal of the literature, there appears to be, no research studies involving this area in Jordan. Therefore, the purpose of this study was to evaluate neuromuscular coordination of hands among physical education students is viable and important.

Research Question

The following question was formulating to achieve the purpose of the study:

What are the differences in neuromuscular coordination among male and female physical education students and among preferred and non-preferred hands?

Research Methodology

Population and Sample

The sample of the study consisted of 305 students selected via random sampling procedures. The participants were assigned

numbers and were entered into computer database. The sample consisted of males and females from rehabilitation, physical education, and sport management departments. The age range was three (18 to 21 years). Students were selected from all academic ranks. The distribution of the sample is shown in Table (1).

Table (1): Sample Description

Variables		N	Percent
Gender	Male	115	37.7
	Female	190	62.3
	Total	305	100
Handedness	Preferred	*305	100
	Non preferred	*305	100
Academic rank	First year	63	20.66
	Second year	89	29.18
	Third year	79	25.90
	Forth year	74	24.26

* These numbers refers using two arm (right and lift for each sample)

Instrumentation

The instrument used to collect data in this study was Soda Pop Test for neuromuscular coordination ability adapted from Hoger & Hoger (2004) which examined the coordination between the eyes – hand. This test was selected because it is simple, easy to use, and takes few minutes to complete. Furthermore, this test has proven to be valid and reliable.

Validity and Reliability of the Instrument

The original English version of the test was developed after: (a) an extensive review of the literature; (b) consultation and

participation by a panel of experts in the area. The test was shown to have both content and face validity. For indication of reliability, the test was studied with 40 students, resulting in an acceptable reliability coefficient of .81 (Hoger & Hoger, 2004).

Instrument translation process

To ensure equivalence of meaning between the process of the Soda Pop Test (SPT) between the Arabic and English versions, a rigorous translation process was used that included forward and backward translation, subjective evaluations of the translated items and pilot testing. The goal of the translation process was to produce an Arabic version of the SPT that were equivalent in meaning to the original English version (Lomi, 1992; Sperber, Devellis & Boehlecke, 1994). Two translators (faculty members), both bilingual in English and Arabic, translated the English version of the SPT into Arabic (forward translation). These translators were asked to retain both the form (language) and the meaning of the items as close as possible to the original, but to give priority to equivalence of meaning. When the Arabic translation was finalized, the SPT was then back-translated (from Arabic to English) by two other faculty members, again both bilingual in English and Arabic.

The back-translated items were then evaluated by five faculty members who have expertise in the field of instructional design, measurement and evaluation, physical education, and motor learning to ensure that the meaning of the process were equivalent in both the original English version and the back-translated version. If differences in meaning were found between them, those process were put again through the forward and backward translation procedures until the faculties were satisfied that there was substantial equivalence of meaning. The finalized Arabic version of the SPT was then pilot tested with a group of 20 students. The feedback from the students did not lead to any substantive changes.

Instrument Standardization

The instrument was pilot tested with a group of 20 students who were enrolled from physical education faculty. These students were then excluded from the actual sample of the study. Based on the pilot test, the test yielded a reliability coefficient of .85 by using test – retest. These figures suggest that the instrument is suitable to measure neuromuscular coordination. The changes recommended by the validation panel and those identified as needed during the pilot test were incorporated into the test.

The Test

The researchers and experts drew a straight line lengthwise through the center of a piece of card-board approximately 32X 5 in wide; they drew six marks exactly 5 in away from each other on the line (draw the first mark about 2½ in from the edge of the cardboard). Using a compass, they drew six circles, each 3¼ in diameter, which was centered on the six marks along the line as in Figure 1.

For the purpose of this test, each circle is assigned a number, starting with 1 for the first circle on the right of the test tackier and ending with 6 for the last circle on the left. The cardboard, three unopened (full) cans of soda pop, a table, a chair, and stopwatch are needed to perform the test.

The cardboard was placed on a table and the person sat in front of it with the center of the cardboard bisecting the body; the preferred hand was used for this test. If this was the right hand, the three cans of soda pop were placed on the cardboard in the following manner: can one centered in circle 1 (farthest to the right), can two in circle 3, and can three in circle 5.

Testing Procedures

The test used in this study was developed by the researchers based on a review of previous research (Hoger & Hoger, 2004). The purpose of this test is to assess overall motor / muscular control and movement time.

To start the test, the right hand was placed with the thumb up; on tin can 1 with the elbow bent at 120°. When the tester gave the signal and the stopwatch began, the can of soda was turned upside down, placing can 1 inside circle 2, followed by can 2 inside circle 4, and then can 3 inside circle 6. All cans, starting with can 1, then can 2, and can3, were turned right side up to their original placement. On this return trip, the can was grasped with the hand in a thumb-down position.

The entire round-trip procedure was done twice, without stopping, and was counted as one trial. Two trips down and up were required to complete one trial. The watch was stopped when the last can of soda pop was returned to its original position, following the second trip back. The preferred hand (in this case, the right hand) was used throughout the entire task. The objective of the test was to perform the task as fast as possible, making sure the cans were always placed within each circle. If the person missed a circle at any time during the test (that is, if the can is placed on a line or outside a circle), the trial must be repeated from the start.

When using the left hand, the participant followed the same procedure, except that the procedures were reversed.

Prior to initiating the test, two practice trials were allowed. Two test trials were administered, and the best time, recorded to the nearest tenth of the second, was used as the test score. If the person has a missed a circle, the test was repeated until two consecutive successful trials were accomplished.

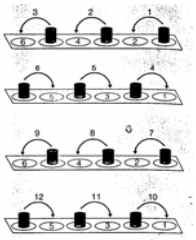

Figure 1

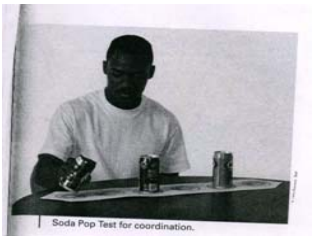

Figure 2

Distinguishing Ability

To examine the experimental validity of the test, the researchers sorted data which were collected from the main sample and selected lower and upper quartiles and compared them between the two groups as shown in Table (2).

Table (2): The Distinguish Ability of the Test

Variables	N	M	SD	T	Sig
High level group	76	7.93	0.55	29.72**	0.001
Low level group	76	11.47	0.101		

Table 2 illustrates that significant differences existed between the two groups which means that the test distinguishes between different abilities and take into account individual differences between the participants.

The Difficulty Coefficient

Kolmogorov-Smirnov Z test was used to examine the range distribution of data collected from test and their coinciding of normal distribution (see Table 3).

Table (3): The Result of Kolmogorov-Smirnov Z Test

Variables	N	M	SD	Z	Sig
Soda Pop Test	305	9.60	1.43	1.139	0.149

The results show that no significant differences exist in the data collected form the test and their coinciding of normal distribution.

Data Collection Procedures

Data collection was gathered from the students by flowing procedures: The researchers obtained a list of student's names from the registration office. A permission to administer the study on campus was obtained from the precedence. A special hall was selected to administer the study and the participants were

informed of the purpose of the study and were assured confidentiality.

Data Analyses Procedures

The SPSS statistical package (version 11.5) was employed to carry out analyses. To answer the research questions, which examined differences in Neuromuscular coordination according to gender (male and females) and handedness (preferred and non-preferred), two- way Anova test was utilized.

Results and Discussion

To achieve the research question, two-way Anova was used. As shown in Table 4 and 5, there were significant differences between males and females in the neuromuscular coordination test for the favor of females. Moreover, there were significant differences between preferred and non-preferred hands for the favor of preferred hand. The tables also shown that there were no interaction between gender and handless

Table (4): The results of two-way Anova for the Effect of Gender and hand on soda Pop Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	27.708	3	9.236	4.715	0.003
Intercept	5306.060	1	5306.060	2708.492	0.001
Gender	14.399	1	14.399	7.350	0.007
Handless	17.789	1	17.789	9.080	0.003
Gender * Handless	6.338	1	6.338	3.235	0.073
Error	589.673	301	1.959		
Total	28754.604	305			
Corrected Total	617.381	304			

Table (5): The results of pair wise comparison for the differences of Gender and handless groups

variables		Mean	Std. Error	groups	Mean Difference	Sig.
Gender	Male	10.71	0.356	Male - female	1.061	0.007
	Female	9.65	0.162			
Handless	Preferred	9.591	0.086	Preferred–non-preferred	-1.179	0.003
	Non-preferred	10.77	0.382			

With the regard to the differences between males and females, these results can be justified with reports that point out to the possibility that females are more efficient in coordinating functions of both cerebral hemispheres compared to males (Gardle, 1975). Neurologically, there is an area in the brain (cerebral cortex) that connect both hemispheres neurologist refer to as the corpus callosum it is speculated by neurologists that this area is larger in females compared to males. (Channel four televisions, 2004). According to (Guyton ,1981) the corpus callosum is a massive net work of nerve fibers that separate anatomically both hemispheres, yet it plays an important role in making information stored in one hemisphere available to the opposing one example right to left or vise-versa.

On the other hand, there is an area in the frontal part of the motor cortex neurosurgeons have called on area for hand skills because if tumot or any other lesions cause destruction in this area, the hand movements become in coordinated and non purposeful, a condition called motor paraxial (Guyton, 1981). Since females may have larger and more massive net work of the corpus callosum nerve fibers, the hand skills area might be more efficient in hand skill motor tasks.

The superiority of females in this study might also be partly explained by the socio-cultural factor in which childhood and preadolescence experience of females are more eye-hand coordination oriented such as playing with toys, sewing, playing

musical instrument, painting and drawing, etc. such small muscle motor acclivities emphasize speed and accuracy which are crucial elements in performing small-muscle motor tasks such as the soda pop test employed in this study.

The results of this study are in agreement with results reported by Silva, Birkbeck, Russel, and Wilson (1984) which indicated the superiority of girls and woman compared to their male counterparts in tasks of fine manual dexterity. Interestingly, the same report indicated that females perform better than males in the perceptual motor behaviors associated with speech and reading as well as in small-muscle simple perceptual motor tasks that require speed, repetition, and skill the soda pop test meets the criteria of simple small-muscle motor tasks.

Finally, on additional Neuromuscular explanation for the superiority of females compared to males in performing simple motor tasks is a study by (Burg, 1968) who reported that females consistently demonstrated slight but significant higher visual fields than males at just about all ages and that female's eye field's peak at a latter age compared to males. Many researchers (Branon & Feist, 2004) believe that vision and visual attributes contribute heavily to the learning and performance of most motor tasks especially in the early stages of practice which applies to the soda pop test employed in this study as a novice, unfamiliar motor task in which both sexes have no prior practice except for the familiarization trial before actually taking the test.

As far as the differences in neuromuscular coordination according to preferred and non-preferred hands, results indicated differences between preferred and non-preferred hands in coordination trend to preferred hand. This result is consistent with results reported by Wilmore (1981) which indicated that males perform better in the preferred hand in baseball throw for distance (which is a gross motor activity) but not in the non-preferred hand which was attributed by the researcher to the past experience of

males in throwing activities using the preferred hand as part of daily motor tasks in most of pre adulthood sports activities of males which actually extends to adulthood male sports activities. Thus, the results of this study regarding the superiority of the preferred hand over the non preferred hand is in agreement with the socio-cultural aspect of skilled performance in gross as well as fine motor tasks. In fact, this is in agreement with the specificity principle of training that works in the adaptation process of both the muscular and / or the neurological dimensions of adaptation to training.

Conclusions and Recommendations

This study was carried out to determine differences in neuromuscular coordination according to gender (males and females) and preferred and non-preferred hands. The study concluded that (a) females are superior to males in neuromuscular coordination, (b) students who used preferred hand outperformed students with non- preferred hand in neuromuscular coordination. Based on these conclusions, the researchers recommended investigating sex differences in fine motor tasks that demand eye-leg (foot) coordination; sex differences in field vision were it would be interesting to conduct more elaborate laboratory tests of field vision such as those reported by singer (1980) which include: The Minnesota rate of manipulation test and Crawford small parts dexterity test. Finally, from a practical standpoint, it is recommended that females are better candidates for jobs and sports that rely on manual dexterity for accurate and efficient performance (e.g., sewing) while males are better candidates for jobs that involve gross motor skills (e.g., heavy duty jobs).

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