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Impact of Circuit Training on Skill Related Neuromuscular Fitness Components (Balance, Coordination and Reaction Time) of Secondary School Level Players; A Quasi-Experimental Single Experimental Group Pretest Posttest Study Design

Sadaf Latif[1], Dr. Faheem Ullah Khan[2], Umme Ammara Nausheen[3], Sobia Mehboob[4], Muhammad Arsalan Abid[5]

1 Physical Training Instructor FGEI Chaklala Cantt Principal Author: sadaflatif826@gmail.com
2 HOD, Department of Sports Sciences and Physical Education MY University Islamabad
3-4 M.Phil. scholars Department of Sports Sciences and Physical Education, MY University Islamabad
5 PhD Scholar Department of Sports Sciences and Physical Education MY University Islamabad

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Abstract

Health is wealth. Physical fitness is a necessity of living a happy life. Without fitness a blessed life become a curse. Skill related fitness components are part and parcel if playing any game or doing a task accurately and perfectly. The importance of skill related neuromuscular fitness components is undoubtedly increasing. The aim of this qusai experimental one group pretest posttest design was to evaluate the impact of 8 weeks' circuit training upon balance, coordination and reaction time of secondary school level girl players. The convenient sampling technique was employed. Total number of 30 players were selected to participate in study. The demographic variables have been recorded and normality of data was analyzed. After recruitment pretest was conducted to collect the pretest data. In the next stage the 8-weeks circuit training plan was implemented administered to experimental group. After intervention phase the posttest data was collected. At final stage the data was analyzed at SPSS. Paired sampled t test was used to compare the means of pretest and posttest scores. Paired sample t test was used to find the difference between the pretest and posttest data of participants. Results demonstrates significant difference between pretest and posttest data of standing balance test. The pretest data (mean=84.6333), posttest data (mean=98.333), t value=13.70, indicates that posttest data was higher as compared to the pretest scores which clearly shows the effect of training. The achieved value of p=.000 which is less than the cutoff value of .05. So the hypothesis H_A1 accepted. Results shown significant difference between the pretest and posttest scores of finger tips touch test for coordination. The pretest data (mean=19.6), posttest data (mean=23.2), t value=15.138, indicates that posttest data was higher as compared to the pretest scores which clearly shows the effect of training. The achieved value of p=.000 which is less than the cutoff value of .05. So the hypothesis H_A2 accepted. Results also demonstrates significant difference between the pre and post test scores of ruler drop test. The pretest data (mean=14.23), posttest data (mean=9.80), t value=-21.392, indicates that posttest data was lower as compared to the pretest scores which clearly shows the effect of training. The achieved value of p=.000 which is less than the cutoff value of .05. So the hypothesis H_A3 accepted.

Keywords: Circuit Training, Fitness, Neuromuscular Components, Balance, Coordination, Reaction Time, Secondary School Level Players

Introduction

Fitness is a state of physical wellbeing that enables individuals to perform daily tasks and activities with energy and efficiency (caspersen et al., 1985). One should be physically fit in order to spend life in a better way. Health is a blessing no doubt. When any one is physically fit, he can perform his daily tasks efficiently, without getting tired. Fitness is usually used in the meanings of physical fitness, related to body capacity of maintaining energy level till the end of all assigned activities. Physical fitness is further classified into health related components and skill related components. Health related components include cardiovascular fitness, body composition, cardiovascular and muscular endurance and flexibility. While skill related fitness components include balance, speed, coordination, reaction time, agility and power. In order to maintain fitness a person must improve all the components of fitness. Fitness is a major term which includes so many aspects. And it is generally classified as health related fitness components and skill related fitness components. According to American college of sports medicine (ACSM, 2022) health related components of fitness are directly related to overall health of an individual and reduces the risk of diseases. And health related fitness components include body composition, flexibility, muscular endurance, muscular strength and cardiovascular endurance. And skill related components are also very important. It includes balance, speed, coordination, reaction time, agility and power. Skill related fitness components are crucial for physical demanding activities and it improves the performance in sports activities (bouchard and shepherd, 2014). This paper is specifically related to the skill related components of fitness specific to neuromuscular. These components improve the performance of individuals in the physically demanding activities and also improves or enhances the performance of individual in context of sports. These skills related neuromuscular components includes the balance, coordination, reaction time, these all are widely recognized and important in the field of sports sciences (bouchard and shepherd, 2014). Balance refers to the ability of body to maintain its center of gravity over the base of support. Balance is further categorized into two basic types' i.e. static balance and dynamic balance. Static balance is the ability of the body to maintain balance while in stationary position. And the dynamic balance refers to the ability of the body to maintain its balance while in motion (winter, 1995). Balance reduces the risk of injury and enhances the stability of posture especially when you getting older, balance gives support (Shumway-cook and Woollcott, 2017). Coordination is the ability of body need to integrate the functions of different body parts. It involves simultaneous use of different body parts in a controlled way (Magill and Anderson, 2017). Coordination depends on the functioning of central nervous system. And its efficiency to synchronize its functions with the muscles. Reaction time refers to the specific time an individual takes to show the abrupt response after getting a stimulus. In short reaction time is the time gap between the stimulus presentation and initiation of the response by the muscles (Schmidt and lee, 2019). It ready the body to tackle in any kind of situation, needs abrupt response. The reaction time is also associated with the coordination. Because it also involves the neural processes. And it can be improved with the help of specifically designed exercises and drills.

Skill related fitness components are further classified into narrow categories including the neuromuscular components of skill related physical fitness components. These neuromuscular components of physical fitness includes balance, coordination and reaction time. These are called neuromuscular because they involves nervous as well as muscular system. They need not only physical muscular movements but the precise control over nervous system as well. Physical activities can improves the fitness level. Regular exercise interventions targeted to specific muscles and specific fitness components and regular sports participation can improve these fitness components (bouchard and shepherd, 2014). Balance is important fitness component need

to do even daily routine based tasks efficiently. Many sports also need balance stability of participants like gymnastics, yoga and surfing etc. Balance can be improved through simple drills regularly. Balance reduces the probability of occurrence of injury in sports man as well as in lay man (Shumway-cool and Woollcott, 2017). Coordination is necessary for smooth execution of movement of different body parts. Ball-handling sports and drills can improve the coordination by synchronizing the movements (magil and Anderson, 2017). Many sports need a very shortest reaction time and these sports in turn increases the reaction time also due to repeated exposure on unpredictable and unexpected situations like in boxing etc. (Schmidt and lee, 2019). Circuit training is a planned structured type of exercise in which the participants have to perform a series of various exercises in an order, each exercise targets the specific muscle or muscle groups designed to improve the specific fitness component. Each sexercise is performed at different station and before moving towards the next station there is always a short interval of rest (gettman and Pollock, 1981). circuit training is a type of exercise which includes combination of different types of exercises like aerobic, power, resistance and skill based which make this type of exercise versatile for fitness of participant. If a station consists of exercises like single leg stand and stability ball exercises, it improves the ability of a body to balance and reduces the risk of injury (Shumway-cook and Woollcott, 2017). Exercises which focus on coordination are essential and necessary for sport specific skills like rope jump i.e. skipping, and medicine ball throws (Magill and Anderson, 2017). Researches also have proved that reaction based stations increases the ability of quick response. These stations sharpen the ability of responding quickly by visual or auditory or any other sensory stimuluses, helps athlete in competitive sports (Schmidt and lee, 2019).

Literature gap

The existing literature have shown that studies concentrated on the health related fitness level i.e. cardiovascular endurance, muscular strength and flexibility (Pereira et al, 2015). While few studies focused on the improvement of agility and power through circuit training plans (Sheppard and young, 2006). These existing researches are sport specific and focused on a specific fitness component. There is a lack of wholesome approach or research which evaluates the impact of circuit training protocols on all the three skill related neuromuscular fitness components in a single holistic intervention protocol. Moreover, there is also related traditional sports specific researches available and conducted but there is lack of specific circuit training plans which integrate all the exercises and protocols which focus on all six neuromuscular fitness components.

Limitations:

All the secondary school level girl players aged between 11 to 15 years from a single school were incorporated in the study.

Objective of the study:

1. To investigate the effects of circuit training (8-week exercise intervention protocol) upon balance.
2. To investigate the effects of circuit training (8-week exercise intervention protocol) upon coordination.
3. To investigate the effects of circuit training (8-week exercise intervention protocol) upon reaction time.

Hypotheses of the study

H_A1: Circuit training (8-week exercise intervention protocol) has significant effect upon ability of balance of secondary level school girl players.

H_A2: Circuit training (8-week exercise intervention protocol) has significant effect upon the ability of coordination of secondary school level girl players.
H_A3: Circuit training (8-week exercise intervention protocol) has significant effect upon the ability of reaction time of secondary school level girl players.

Methods and Materials:
This section of the research shows the strategies, processes or methods utilized in the collection of data or evidence for analysis in order to uncover latest information.

Study Design:
The qusai experimental research design was used to determine the effects of circuit training (8-week exercise intervention protocol) on skill related neuromuscular components of fitness.

Population:
The population for the given study comprised of secondary level girl's players enrolled in FG girl's public school tariqabad.

Inclusion criteria:
Secondary school level girl players
Age between 11-16 years
No medical disease history

Sample:
Total 30 students participated in school games. Total population was taken as a sample population for the study. No any sampling method was chosen because the population of interest was not large.

Equipment:
Stop-watch, measuring tape, cone markers.

Recruitment of sample:
Before the final recruitment of samples for the research, the participants were provided with the informed consent form, and explain all the necessary details of the research objectives by the researcher. The participants were assuring about their confidentiality and safety. All the participants signed the informed consent forms and finally recruited themselves in the given research study willingly. After the final recruitment of samples into the study, the data regarding demographic variables have been collected from the participants. And according to inclusion criteria finally recruited the sample into the study.

Pre-Test:
In the next step the data regarding the skill related neuromuscular components i.e. balance, coordination and reaction time have been collected as pretest data. In order to measure the balance of participants standing balance test have been conducted in which the static balance of participants have been measured. The participants were asked to stand on each leg one by one as long as she can. The time was noted in seconds. In order to measure the coordination level of participants, the finger tips touch test have been conducted. This test measures the fine motor coordination. The scoring has been marked and noted. And in order to measure the reaction time of participants, the ruler drop test have been conducted. And data was collected in cm. The pretest data related to three neuromuscular skill related components of physical fitness have been compiled on the score sheets arranged separately for each component.

Treatment:
After collecting the pretest data from the participants, the next step was intervention phase, in which the treatment was given to the participants. The circuit training plan was followed by the participants, consecutive eight weeks. 4 days a week with three days' rest. The circuit training protocol containing the six stations consists of 30-minute session per day. Each station had specific exercise for improvement of each skill related fitness component. After each station there is break of a minute. The training plan was of slow to moderate intensity.

Posttest:
After the implementation of eight-week circuit training plan the post test was conducted to collect the data. Same tests were conducted by researcher with the assistance of school coach to collect the data regarding the skill related components as in the pre-test.

Data analysis procedure:
To describe the characteristics of data descriptive statistics were used and the collected data were tabulated and analyzed with the help of SPSS version 21.

Descriptive statistics:

Table1: Frequency distribution of age of participants.

	Frequency	Percent	Valid Percent	Cumulative Percent
11	2	6.7	6.7	6.7
12	4	13.3	13.3	20.0
13	5	16.7	16.7	36.7
14	8	26.7	26.7	63.3
15	7	23.3	23.3	86.7
16	4	13.3	13.3	100.0
Total	30	100.0	100.0	

Table 1 showing there were total 30 participants in the given study. 2 (6.7%) were of 11 years, 4 (13.3%) were of 12 years, 5 (16.7%) were of 13 years, 8 (26.7%) were of 8 years, 7(23.3%) were of 15 years and 4 (13.3%) were of 16 years.

Table2: frequency distribution of height of participants

	Frequency	Percent	Valid Percent	Cumulative Percent
153.0	13	43.3	43.3	43.3
155.0	7	23.3	23.3	66.7
156.0	1	3.3	3.3	70.0
158.0	1	3.3	3.3	73.3
161.0	1	3.3	3.3	76.7
162.0	2	6.7	6.7	83.3
165.0	3	10.0	10.0	93.3
168.0	2	6.7	6.7	100.0
Total	30	100.0	100.0	

Table 2 showing the data regarding the height of participants. The table shows that 13(13%) participants were of 153 cm height, 7(23.3%) were of 155cm, 1(3.3%) was of 156 cm, 1(3.3%) was of 158 cm, 1(3.3%) was of 161cm, 2(6.7%) were of 162 cm, 3(10%) were of 165 cm and 2(6.7%) were of 168cm height.

Table 3: frequency distribution of weight(kg) of participants

	Frequency	Percent	Valid Percent	Cumulative Percent
30.00	7	23.3	23.3	23.3
38.00	1	3.3	3.3	26.7
39.00	1	3.3	3.3	30.0
40.00	4	13.3	13.3	43.3
41.00	2	6.7	6.7	50.0
43.00	1	3.3	3.3	53.3
44.00	1	3.3	3.3	56.7
45.00	2	6.7	6.7	63.3
46.00	1	3.3	3.3	66.7
48.00	2	6.7	6.7	73.3
49.00	1	3.3	3.3	76.7
50.00	3	10.0	10.0	86.7
56.00	2	6.7	6.7	93.3
60.00	1	3.3	3.3	96.7
62.00	1	3.3	3.3	100.0
Total	30	100.0	100.0	

Table 3 showing the frequency distribution of weight of participants. 7(23.2%) participants were having weight 30kg, 1(3.3%0 was having 38kg, 1(3.3%) was having 39kg, 4(13.3%) were having 40kg, 2(6.7%) were having 41 kg, 1(3.3%) was having 43kg, 1(3.3%) was having 44kg, 2(6.7%) were having 45kg, 1(3.3%) was having 46kg, 2(6.7%) were having 48kg, 1(3.3%) was having 49kg, 3(10%) were having 50kg, 2(6.7%) were having 56kg, 1(3.3%) was having 60kg and 1(3.3%) was having 62kg weight.

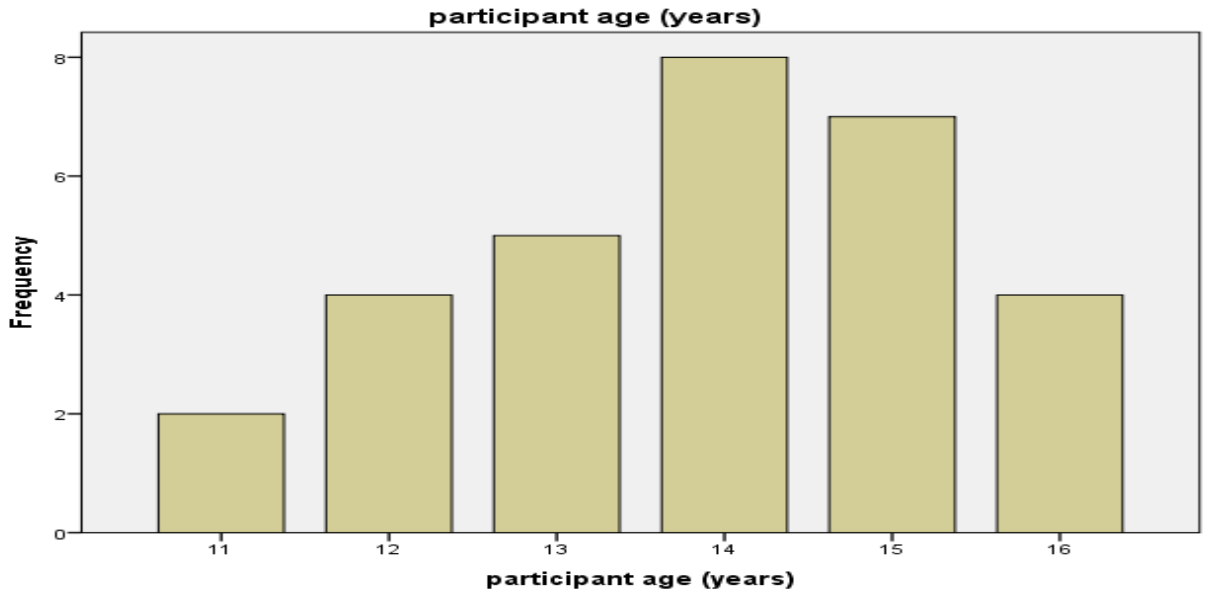

Figure 1: showing the bar graph of age of participants.

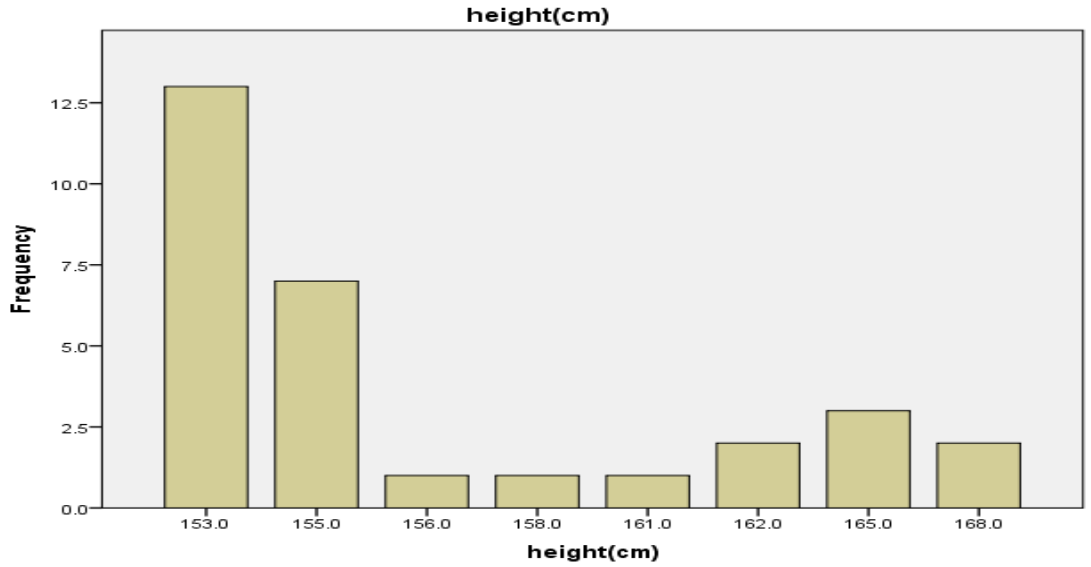

Figure2: showing the bar graph of height of participants

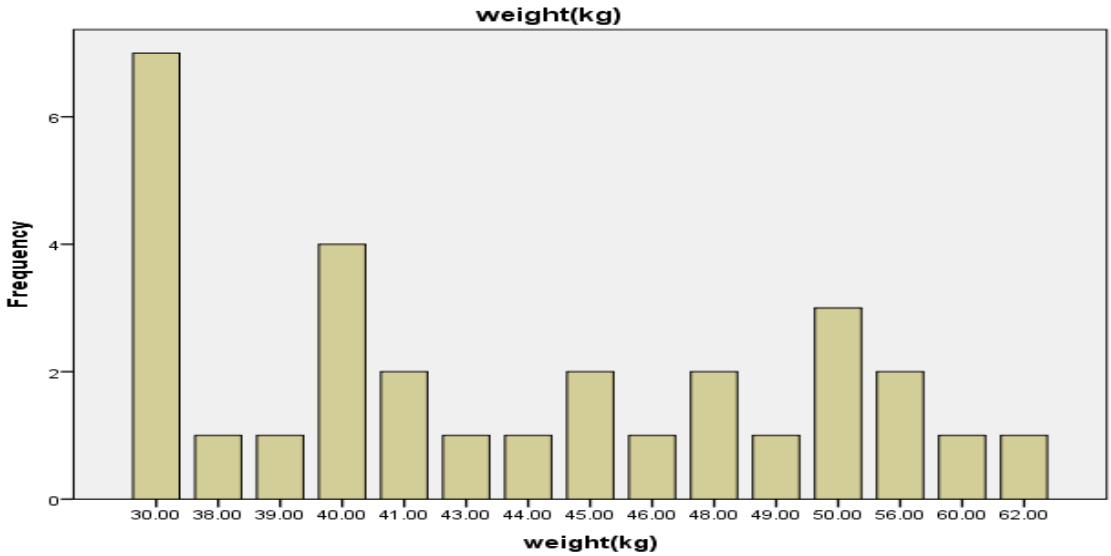

Figure3: showing the bar graph of weight of participants.

Data normality test:

Table 4: summary table of participants demographics

Variables	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
participant age (years)	30	100.0%	0	0.0%	30	100.0%
height(cm)	30	100.0%	0	0.0%	30	100.0%
weight(kg)	30	100.0%	0	0.0%	30	100.0%

Table 4 indicates that there were 30 girl players were participated in the study.

Table 5: data normality tests of variables

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
participant age (years)	.170	30	.027	.932	30	.054
height(cm)	.306	30	.064	.748	30	.080
weight(kg)	.147	30	.095	.934	30	.062

Table 5 shows that the data of all 30 participants was suitable for parametric test according to these variables i.e. participant's age, height and weight because their sig. values were greater than 0.05 which indicates that the data of participants was normal with reference to age, height and weight.

Hypothesis testing:

Analysis of H_A1:

H_A1: circuit training (8-week exercise intervention protocol) has significant effect upon ability of balance.

Table 6: Paired Samples Statistics

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	pretest score	84.6333	30	22.48138	4.10452
	posttest score	98.3333	30	22.73435	4.15071

Table 6 shows the paired samples statistics results. The results of paired samples statistics show that the mean scores of participants in the pretest was 84.6333, SD was 22.48138, and in the posttest the mean score was 98.333 and SD was 22.73435. It indicates that, the participants scored high in the posttest as compared to the pretest. The standard error of the mean was 4.10452 in the pretest and 4.15071 in the posttest. This very small value of standard error mean indicated that the mean value was most reliable estimates of the population values.

Table 7: Paired Samples Correlations

		N	**Correlation**	**Sig.**
Pair 1	pretest score & posttest score	30	.963	.000

The table 7 shows the paired samples correlations. The results of paired samples correlation indicate that the correlation was 0.963 between the pretest and posttest scores. Suggesting that there was strong positive correlation between the pretest scores and posttest scores. The significance value was 0.000 indicates that this strong positive correlation was statistically significant. Indicated that this correlation was not by chance.

Table 8: Paired Samples Test

		Paired Differences			
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference Lower**
Pair 1	pretest score - posttest score	13.70000	6.15966	1.12459	16.00005

Table 9: Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference	T	Df	Sig. (2-tailed)
		Upper			
Pair 1	pretest score - posttest score	11.39995	12.182	29	.000

Table 8 and 9 shows the results of the paired sample t test scores. These results shows that mean of paired differences was 13.7 with standard deviation 6.15966, standard error mean 1.12459. And the 95% confidence interval lies between the 11.39 and 16.000, indicating that after the protocol, participant's scores raises from 11 to 16. The results of the t test indicate that the t value was 12.182, means that the difference between the pretest and posttest was greater. The p value was 0.000 indicates that the difference was statistically significant.

Result: the results of the paired sample t test supports the hypothesis: 'circuit training (eight week exercise intervention protocol) has significant effect upon balance of secondary level school girl players'. And the hypothesis was accepted.

Hypothesis testing:

H_A2: circuit training (8-week exercise intervention protocol) has significant effect upon the ability of coordination.

Table 10: Paired Samples Statistics

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	pretest score	19.6000	30	3.81105	.69580
	posttest score	23.2000	30	4.13897	.75567

Table 10 shows the mean value of pretest and posttest scores, the standard deviation and standard deviation error mean. The results indicate mean value of pretest scores was 19.6000, with standard deviation 3.81105. And standard error of mean of .69580. The posttest scores mean was 23.2000, with standard deviation 4.13897 and standard error mean was 0.75567. Indicating that sample mean was reliable estimate.

Table 11: Paired Samples Correlations

		N	**Correlation**	**Sig.**
Pair 1	pretest score & posttest score	30	.950	.000

Table 11 shows the correlation between pretest and posttest scores. The value of correlation between pretest and posttest was 0.950 and its significance value is 0.000. Such great value of

correlation indicates these two sets of scores are strongly related. And this correlation is statistically significant.

Table 12: Paired Samples Test

		Paired Differences			
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference Lower**
Pair 1	pretest score - posttest score	3.60000	1.30252	.23781	4.08637

Table 13: Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference Upper	**t**	**Df**	**Sig. (2-tailed)**
Pair 1	pretest score - posttest score	3.11363	15.138	29	.000

Table 12 and 13 shows the paired differences mean with standard deviation and standard error mean. It also indicates the upper and lower value of 95% confidence interval of this difference. T value 0f 15.138 indicates that there are 15.138 scores difference between the pretest and posttest scores. The sig value of 0.000 indicates that this difference is statistically significant.

Result: the results of the paired sample t test supports the hypothesis: ‘circuit training (eight-week exercise intervention protocol) has significant effect upon coordination of secondary level school girl players’. And the hypothesis was accepted.

H_A3: circuit training (8-week exercise intervention protocol) has significant effect upon the the ability of reaction time.

Table 14: Paired Samples Statistics

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	pretest score	14.2333	30	1.27802	.23333
	posttest score	9.8000	30	1.09545	.20000

Table 14 shows the mean value of pretest and posttest scores, the standard deviation and standard deviation error mean. The results indicate mean value of pretest scores was 14.2333, with standard deviation 1.27802. And standard error of mean of 0.23333. The posttest scores mean was 9.8000, with standard deviation 1.09545 and standard error mean was 0.2. Indicating that sample mean was reliable estimate.

Table 15: Paired Samples Correlations

		N	**Correlation**	**Sig.**
Pair 1	pretest score & posttest score	30	.552	.002

Table 11 shows the correlation between pretest and posttest scores. The value of correlation between pretest and posttest was 0.552 and its significance value is 0.002. Such great value of correlation indicates these two sets of scores are strongly related. And this correlation is statistically significant.

Table 16: Paired Samples Test

		Paired Differences			
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference
					Lower
Pair 1	pretest score - posttest score	4.43333	1.13512	.20724	4.00947

Table 17: Paired Samples Test

		Paired Differences	t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference			
		Upper			
Pair 1	pretest score - posttest score	4.85720	-21.392	29	.000

Table 16 and 17 shows the paired differences mean with standard deviation and standard error mean. It also indicates the upper and lower value of 95% confidence interval of this difference. T value 0f -21.392 indicates that there are 21.392 scores difference between the pretest and posttest scores. The negative sign shows that the posttest scores were smaller as compared to pretest scores. The sig value of 0.000 indicates that this difference is statistically significant.

Result: the results of the paired sample t test supports the hypothesis: ‘circuit training (eight-week exercise intervention protocol) has significant effect upon reaction time of secondary level school girl players’. And the hypothesis was accepted.

Summary:

Circuit training plays an important role in improving the neuromuscular skill related fitness components i.e. balance, coordination and reaction time. Because circuit training involves quick changes in stations which involves quick mental response and muscular coordination. In this way it enhances the neuromuscular abilities of the participant. The main objective of this research paper was to find out the effects of circuit training on balance, coordination and reaction time on secondary school level girl players. Various studies have been conducted globally to investigate these facts. Taking into the consideration these studies, formulated the research design for this qusai experimental study. The students of FG girls public school tariqabad were the selected population of this study. Age limit from 11 to 16 years. Demographics were collected after following all ethical considerations. Pretest scores were recorded using standing balance test for balance, finger tips touch test for coordination and ruler drop test for reaction time. The eight weeks’ circuit training plan was designed for study. The protocol was implemented after validation from the fitness trainer experts. The treatment comprised of circuit training activities consists of stations that include shuttle run, standing on one leg with ball throws with wall, jump squats, high knee sprints and juggling with ball. The protocol includes warm up and cool down sessions also. And follows the scientific principles of training. After eight weeks of implementation of treatment, the posttest scores were recorded. The collected data was analyzed by SPSS version 21and used paired sample t-test for determining the significance between the mean value of pretest scores and posttest scores.

Conclusion:

On the basis of findings of the tests, it was concluded that circuit training improves the balance, coordination and reaction time i.e. neuromuscular components of fitness. In any sports and also in your daily activities everyone needs strong connection of nervous system and muscular system for quick response of any stimulus. For getting command over any sports, these skills are necessary. In the present study, the pretest mean value of standing balance was 84.6333, finger tips touch was 19.6 and ruler drop was 14.23. After eight weeks of circuit training protocol the posttest data was recorded. The posttest mean value of standing balance was 98.333, finger tips touch was 23.2 and ruler drop test was 9.80. According to analysis results it is concluded that circuit training improves balance, coordination and reaction time components which is essential for players to show good performance in sports activities.

Recommendations:

On the basis of findings of study, the following recommendations are hereby proposed:

1. As the results show that the circuit training improves the balance, coordination and reaction time, therefore it is suggested that the people should be aware about the importance of circuit training for improving their neuromuscular fitness.
2. The physical education teachers and coaches should prepare sports activities and motivate the students to engage in circuit training.
3. The trainers and coaches should make the circuit training as part of their protocols.
4. Further studies should be conducted to verify the findings, with large number of sample.

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