Research Paper

Transient Change in Core Strength, Endurance, and Upper Limb Isometric Strength After Core Stabilisation Knockdown Protocol in Female Athletes

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ABSTRACT

Objectives: We assessed the effect of change in core isometric strength and endurance on upper limb isometric strength in female athletes.

Methods: In this experimental study, 32 female athletes aged 18-25 years were recruited based on the inclusion criteria. (17 cases in the experimental group and 15 cases in the control group). Before and after the core stabilization knockdown protocol, participants were assessed for isometric core strength (abdomen/back rehab 5310; rehab line), core endurance (curl-up test), and upper limb isometric strength (push up/pull down rehab 5120; rehab line).

Results: The results showed a significant reduction in abdomen, back, push-up, pull-down isometric strength, and curl-up test scores in the experimental group and no significant differences in these parameters in the control group after the protocol. The experimental and control groups showed significant differences in the aforementioned parameters after the protocol.

Discussion: This research suggests that performing extensive and exclusive core exercises to relieve fatigue prior to upper limb training can decrease the potential for core activation. This can ultimately lead to reduced effectiveness of upper extremity exercises or rehabilitation sessions, which can lead to upper body injuries. These exercises can be useful to enhance the knowledge regarding the sequencing of core and upper limb exercises in an athlete's training protocols.

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Highlights

• Core strength is a crucial component in maximizing upper limb performance.

• There is a relationship between core activation/stabilization and isometric strength of muscles surrounding the shoulder.

• Exclusive core training should be done after an upper body workout, not before, and additionally, core exercises should be integrated with upper body workouts.

Plain Language Summary

Enhancing core stability is essential to improve athletic performance. It has been demonstrated that enhanced trunk stability further promotes athletic performance by laying the groundwork for increased limb force and generation of power. It is believed that optimal core strength will enable an athlete to effectively transfer forces from the lower extremities to the upper extremities through the torso. The current study found a corresponding significant reduction in upper limb isometric strength with momentary alteration in core strength and endurance, which was greater in pull down exercise group than push up muscle group, suggesting that performing extensive and exclusive core exercises to relieve fatigue before upper extremity training can reduce the potential for core activation. Therefore, athletes and coaches should consider that exclusive and extensive core training should be done after an upper-body training session, not before, and additionally, core exercises should be integrated with upper-body workouts.

Introduction

The lumbopelvic hip complex commonly known as the core is basically a box with its bottom composed of the pelvic floor and hip girdle musculature, the diaphragm as the roof, abdominals, and obliques in the front and paraspinal and gluteals in the back [1]. Core muscles provide the strong foundation needed for limb function and force transmission [2]. Enhancing core stability is essential to improve athletic performance [3]. Controlling core strength, balance, and motion also maximizes all kinetic chains of upper and lower extremity function, as the core is key to practically all kinetic chains of sports activities [4]. Athletes are believed to be better able to fully transfer forces generated by their bottom extremities through their torso, to their upper extremities, and occasionally to an object if they have a strong core [5, 6]. The disruption of energy flow caused by a weak core is thought to impair athletic performance and raise the possibility of damaging a muscle group that is already underdeveloped or weak [7].

The core muscles play a very remarkable role in the stability and movement of body parts, assisting in the mobility of upper and lower limbs against gravity thereby facilitating arm and leg function [4, 8, 9]. The demand for whole-body exercise performance responses acts as a bridge between the upper and lower limbs, providing a stable basis and transferring force to the extremities [2, 10, 11]. The perfect performance of the upper extremities depends not only on shoulder girdle force control but also on trunk and pelvic stabilizing force [12]. Local and global stabilizers are used to obtain the best core stability. The abdominal muscles, erector spine, latissimus dorsi, and hip abductors are big global stabilizers that create the necessary power and stability for upper extremity activity [13].

Shoulder and elbow injuries have been linked to a lack of core stability [12]. According to the kinetic chain theory, aberrant neuromuscular control in any part of the chain can change the forces and biomechanics of upper-extremity movements [14]. Training of the trunk musculature, particularly the abdominal muscles, has become an important component of many fitness programs [15]. For justification, it has been demonstrated that enhanced trunk stability enhances athletic performance by laying the groundwork for increased limb force and power generation [16]. There is no study in the literature that relates the activation or stability of the core to the isometric strength of the muscles that surround the shoulder. Therefore, there is a need to correlate changes in core muscle strength and endurance with variations in upper limb strength. Therefore, the goal of this study was to determine how changes in core strength and endurance affect female athletes' upper limb isometric strength.

We investigated the transient change in core isometric strength, endurance, and upper extremity isometric strength after a core stabilization knockdown protocol (CSKP) in female athletes. It was hypothesized that upper limb isometric strength significantly varies with transient change in core strength and endurance in female athletes using the CSKP.

Materials and Methods

In this experimental study, 34 female athletes participated and were randomly assigned to the control and experimental groups (17 participants per group) using the chit technique. However, in the control group, two women were not willing to evaluate; thus, 17 girls participated in the experimental group and 15 in the control group. While the assessor was aware of the treatment being administered to the subject, participants were blinded for the intervention. The participants had a minimum of three years of experience and engaged in training with a frequency of at least three sessions per week that included workouts for the entire body's musculature. Participants were disqualified if they had recently undergone surgery on an upper limb, suffered from musculoskeletal pain in that limb, or had a neurological or cognitive disability, musculoskeletal disorder, or injury affecting the study's outcome [2]. The study was carried out at the GNDU Department of Sports Sciences and Medicine, MYAS (Ministry of Youth Affairs and Sports), Amritsar, Punjab. Using G*Power 3.1.9.7, the sample size was calculated. The study's threshold of significance was set at 0.05 and its power was set to 80% (0.84). The study was carried out following the Helsinki Declaration (2013) and the national ethical guidelines for biomedical & health research involving human participants published by the Indian Council of Medical Research in 2017. Figure 1 shows a CONSORT diagram that depicts how participants moved through the various phases of the study.

Procedure

Before the procedure commenced, the subjects were requested to complete the consent form. They were informed that participation in the study was entirely voluntary and they could discontinue at any moment. Risks and potential benefits were also explained to all the subjects. The participants had no prior exposure to the protocol (CSKP). Participants were asked to warm up for 5-10 minutes, including stretching of upper limb muscles to prevent any sort of muscular discomfort/injury afterward.

Session 1: It included a curl-up test and measurement of isometric shoulder and abdomen/back strength.

Curl-up test

Subjects were instructed to slowly bend over while contracting their abdominal muscles, moving their hands up their thighs until their fingertips touched the tops of their knees, and then slowly returning to the starting position. The number of overall curls was noted [17].

1) Isometric abdomen/back strength by HUR 5310 abdomen exercise: The action was carried out by gently pressing the lever arm downward with the abdominal muscles while holding onto the roller with the hands.

2) Left abdominal exercise: The subject sat on the seat with her left side up. The athlete pushed the lever arm downward using her core muscles.

3) Right abdominal exercise: The patient slid onto the seat with her right side up. Pushing the lever arm required the athlete to use her abdominal muscles.

4) Back exercise: With hands crossed across the chest, the exercise consisted of moving the lever arm downward with the lower back muscles (HUR Analogue Machines Owner's manual3310/5310 Abdomen/Back, 2021) (Figure 2).

Isometric shoulder strength by HUR 5120

1) Push-up movement

2) Pull-down movement (HUR analog machines owner's manual 3120/push up/pull down rehab 5120, 2021) (Figure 3)

Session 2: It included the performance of each exercise included in the novel CSKP till voluntary exhaustion (Figure 4) [18, 19]. Raabe et al. [18] created this methodology to assist in investigating the impact of core stability on several biomechanical variables. The CSKP comprises four dynamic and four isometric exercises to target both the superficial and deep core musculature with little involvement of the lower extremity muscles. A floor mat, a BOSU® ball, and a Swiss ball were used. The assessor demonstrated the exercise before the protocol and also showed flash cards of each exercise during the performance.

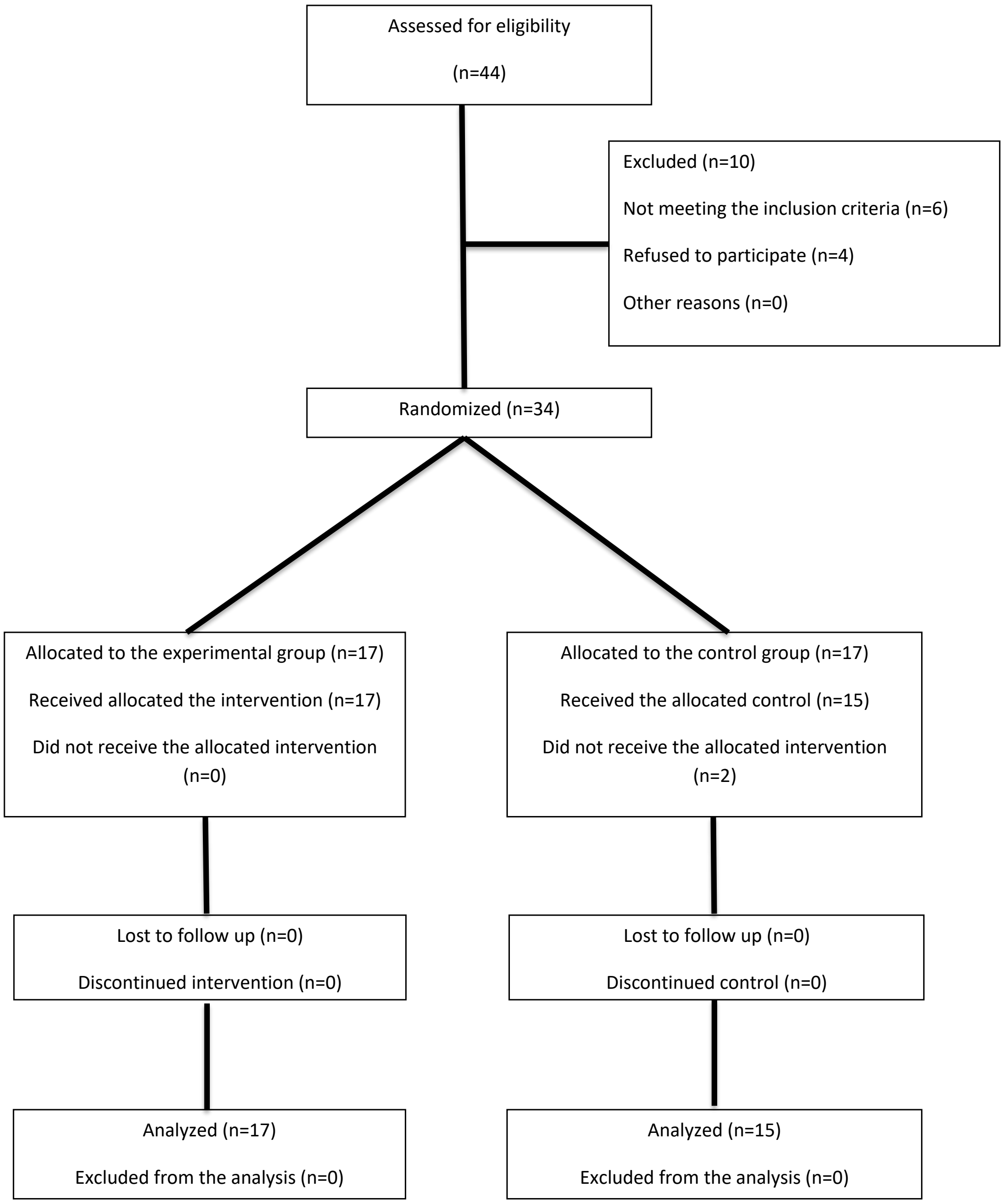

Figure 1. The CONSORT diagram indicating the flow of participants through each stage of the study

Session 3: After a rest of 1 minute after the protocol, the measurement was recorded again. For the control group, sessions one and three were conducted with a rest period of 5 minutes in between without the CSKP.

Statistical analysis

SPSS software, version 26 was used to analyze the data. The Shapiro-Wilk test revealed that the data were normally distributed. To compare the pre- and post-CSKP data within the experimental and control groups, a paired t-test was utilized. To compare the pre- and post-CSKP data between the experimental and control groups, an independent t-test was utilized. Any test with a $P\leq0.05$ was judged significant.

Results

An anthropometric measurement descriptive analysis was completed (Table 1). The Shapiro-Wilk test revealed that the data were normally distributed. The paired t-test showed a significant difference between pre- and post-values of the abdomen, back, push-up, and pull-down isometric strength in the experimental group (Table 2).

Table 1. Anthropometric data of the subjects

Characteristics	Mean±SD	
	Experimental Group	Control Group
Age (y)	21.47±1.586	21.67±1.759
Weight (kg)	53.88±8.169	55.47±5.125
Height (m)	1.59±0.060	1.6333±.07058
Body mass index (BMI) (kg/m^2)	21.12±1.76	20.81±1.74

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Additionally, an independent t-test was used to determine any between-group differences (Table 3). The pre-CSKP values for abdomen, back, push-up, pull-down, and core endurance were similar at baseline and not significantly different between the experimental and control groups. The isometric measured force values of the abdomen, back, push-up, pull-down, and core endurance post-CSKP showed significant differences between the experimental and control groups. This means that CSKP led to significant primary changes in the abdomen and back strength, which further led to significant secondary changes in push-up and pull-down strength in the experimental group. However, no remarkable changes were observed in values of the left and right abdomen after CSKP within both experimental and control groups. The isometric measured force values of the left and right abdomen pre- and post-CSKP showed no significant differences between the experimental and control groups. As a result, CSKP had no discernible impact on the lateral core muscles' strength. According to the existing literature, there is no direct correlation between the strength of the upper limb isometric muscles and the strength of the lateral core muscle group.

Table 2. Comparison of outcome measures within groups

Parameter	Group	Mean±SD		t	P
		Pre-CSKP	Post-CSKP		
Abdomen (kg)	Experimental	135.62±15.9952	120.571±27.4482	2.682	0.016
	Control	141.80±20.7963	148.66±30.0251	-1.247	0.233
Back (kg)	Experimental	176.100±60.447	147.206±48.5857	3.482	0.003
	Control	166.033±22.813	178.473±37.2679	-1.457	0.167
Left abdomen (kg)	Experimental	140.612±47.203	136.512±34.4569	0.394	0.699
	Control	148.207±21.795	153.213±20.6740	-0.867	0.401
Right abdomen (kg)	Experimental	142.071±45.218	134.012±40.7685	1.260	0.226
	Control	146.393±25.699	150.173±24.0899	-0.786	0.445
Push-up (kg)	Experimental	290.106±82.859	263.712±71.9601	3.879	0.001
	Control	280.953±60.583	318.180±74.3415	-1.920	0.075
Pull-down (kg)	Experimental	234.159±42.412	221.600±44.1845	2.253	0.039
	Control	206.807±38.495	178.247±54.1792	2.081	0.056
Curl-ups	Experimental	50.47±9.850	31.71±11.936	10.462	0.000
	Control	53.93±10.734	45.67±11.069	2.985	0.010

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CSKP: Core stabilisation knockdown protocol; SD: Standard deviation.

Table 3. Comparison of outcome measures between groups

Parameter	Pre-/Post-CSKP	Mean±SD		t	P
		Experimental	Control		
Abdomen (kg)	Pre-CSKP	135.624±15.995	141.807±20.7963	-0.933	0.359
	Post-CSKP	120.571±27.448	148.660±30.0251	-2.749	0.010
Back (kg)	Pre-CSKP	176.100±60.447	166.033±22.8139	0.637	0.531
	Post-CSKP	147.20±8.5857	178.473±37.2679	-2.055	0.049
Left abdomen (kg)	Pre-CSKP	140.612±47.203	148.207±21.7955	-0.595	0.557
	Post-CSKP	136.512±34.456	153.213±20.6740	-1.684	0.104
Right abdomen (kg)	Pre-CSKP	142.071±45.218	146.393±5.6999	-0.337	0.739
	Post-CSKP	134.012±40.768	150.173±4.0899	-1.384	0.178
Push-up (kg)	Pre-CSKP	290.106±82.859	280.953±60.5830	1.912	0.065
	Post-CSKP	263.712±71.960	318.180±74.3415	-2.100	0.045
Pull-down (kg)	Pre-CSKP	234.159±42.412	206.807±38.4951	-0.946	0.352
	Post-CSKP	221.600±44.184	178.247±54.1792	2.460	0.021
Curl-ups	Pre-CSKP	50.47±9.850	53.93±10.734	-0.946	0.352
	Post-CSKP	31.71±11.936	45.67±11.069	-3.432	0.002

CSKP: Core stabilisation knockdown protocol; SD: Standard deviation.

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Hence, CSKP leads to a transient change in core strength and endurance, which affects upper limb isometric strength. CSKP leads to a reduction in core strength and endurance. This temporary reduction in core strength and endurance further reduces the potential of upper limb strength, thereby establishing a direct relationship between momentary core strength and endurance and upper limb isometric strength.

Discussion

The aim of the study was to explore the transient change in core isometric strength, endurance, and upper limb isometric strength after CSKP in female athletes.

Abdomen and back isometric strength significantly reduced after CSKP in the experimental group, while there were no significant changes within the control group. Also, there were notable and significant differences in the abdomen and back isometric strength values after CSKP between experimental and control groups, while baseline values were not significantly different. CSKP significantly altered abdomen and back strength temporarily in female athletes. Raabe et al. (2019) found that the CSKP was successful in lowering a person's core stability transiently [18]. Further, Chaudhari et al. (2020) reported that CSKP elicited a significant moderate level of muscle fatigue in rectus abdominis and L5 lumbar extensors using the median frequency of the surface electromyography [19]. This explains the significant reduction in abdomen and back isometric strength after CSKP was reported in the present study.

The present study discovered no remarkable difference in the baseline values of core endurance between the experimental and control groups while the differences in core endurance values after CSKP between the groups were significant. Furthermore, there were significant differences pre- and post-core endurance scores measured using the curl-up test within both the studied groups. In the experimental group, the reason for this significant variation can be explained by performing CSKP, which was used to exhaust the core musculature and hence, there was a reduction in the repetitions of the curl-up test. On the other hand, no such protocol or exercise was performed by the control group. In addition, the surprising significant differences occurred. The reason for this variation can be attributed to fatigue due to the curl-ups performed during the measurement of baseline values and the altered willingness of the participants to perform again. It was reported that an athlete's core endurance and upper and lower extremity muscle strength are linked [20].

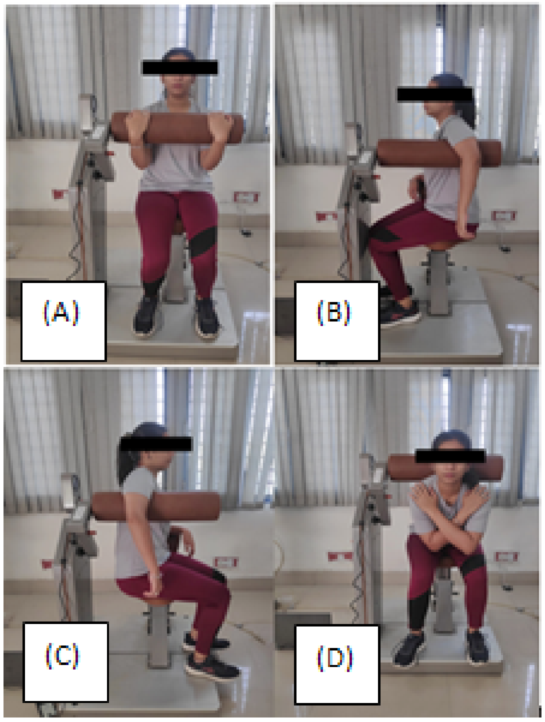


Figure 2. Isometric abdomen/back strength by HUR 5310

A) Abdomen, B) Left abdomen, C) Right abdomen, D) Back

We found a significant decrease in abdomen/back isometric strength and endurance from baseline values after the CSKP. Corresponding reductions in isometric upper extremity push-up and pull-down strength were also found. Also, the comparison of CSKP values after push-up and pull-down was significant between the groups, while the baseline values were not significantly different. Our findings are consistent with various studies directly and indirectly. Almost all kinetic chains in sports activities revolve around the core. The function of the kinetic chains in the upper and lower extremities is maximized by the control of core strength, balance, and motion. As a result, distal mobil-

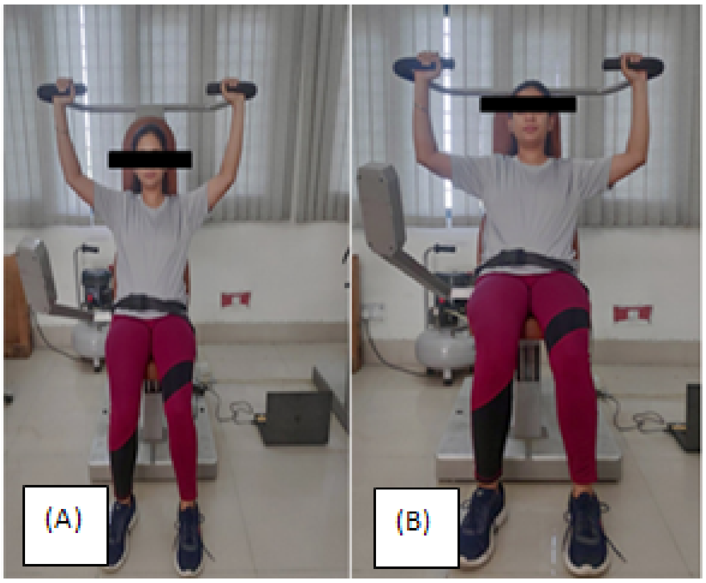


Figure 3. Isometric shoulder strength by HUR 5120

A) Push-up, B) Pull-down

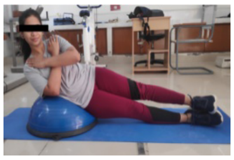
Exercise	Description
 1 & 2. Side bends repetitions on BOSU® ball (L&R)	Participants were instructed to lie on their sides with their hips stacked on top of each other and their arms folded in front of them. Athletes were instructed to move through their whole range of motion slowly. Athletes were instructed to repeat the activity until they were completely exhausted.
 3. Back extension repetitions on BOSU® ball	Athletes were told to lie down on their belly and cross their arms in front of them, relax their legs and gluteal muscles as much as possible, and move through their full range of motion slowly and deliberately. Athletes were instructed to repeat the activity until they were completely exhausted.
 4. Swiss ball crunches	Athletes were instructed to cross their arms in front of them and move through the entire range of motion while engaging their core muscles. Athletes were instructed to repeat the activity until they were completely exhausted.
 5 & 6. Side plank hold	Athletes were instructed to lie on their sides, stack their hips as high off the ground as possible, and hold this position for as long as possible.
 7. Back extension hold	Athletes were instructed to lie down on their belly and keep their hands on their lower back while raising their chest off the ground as high as possible and keeping their legs on the ground. Athletes were instructed and encouraged to relax their legs and gluteal muscles. Athletes were asked to hold this position for as long as they could.
 8. Traditional plank hold	Athletes were told to place their forearms on the ground and raise their bodies into a plank position such that their hips and shoulders were aligned. Athletes were instructed to stay in this position for as long as possible.

Figure 4. Core stabilisation knockdown protocol [19]

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ity is made more proximally stable [13]. It is believed that a strong core will enable an athlete to effectively transfer forces from the lower extremities through the torso to the upper extremities [5, 6, 16]. The correlation between upper limb strength and core stability is moderate [11]. Strong core stability reduces stress on the spine while simultaneously increasing the strength and endurance of the peripheral joints and enabling energy to be transferred to the extremities [21].

On the other hand, when the core muscles are exhausted using a protocol that consists of just two exercises—the flexion-hold and extension-hold tests— the shoulder muscle's maximal voluntary isometric contraction (MVIC) significantly decreases in the frontal and transverse planes [22]. Hence, performing core exercises to relieve fatigue prior to upper limb training can decrease the potential of core activation and eventually lead to upper limb training or rehabilitative sessions being less effective. Also, shoulder and elbow injuries have been linked to a lack of core stability [12, 23]. In individuals with distal arm injuries, core stabilization improved movement patterns by increasing proximal stability [24]. Therefore, temporary alteration in core strength due to exhaustion can significantly reduce upper limb strength and power required for various exercises in upper body training and conditioning sessions. It has been established that optimal core activation and stabilization are required for any sort of distal extremity movement. This gives us an insight into prioritizing integrated core and upper body strengthening exercises rather than going for an extensive isolated core strengthening regime.

Conclusion

The present study concludes that CSKP significantly reduces abdomen and back isometric measured forces (kg). This alteration in abdomen and back strength further reduced push-up (pectoralis major, deltoid, and triceps brachii) and pull-down (biceps brachii, latissimus dorsi, infraspinatus, teres major, and teres minor) isometric strength from the baseline values measured prior to the CSKP. Meanwhile, no significant alteration occurred in the values of right and left abdomen isometric measured forces (kg) and this insignificant change was not effective in the reduction of upper limb isometric strength. This research suggests that performing extensive and exclusive core exercises to relieve fatigue prior to upper limb training can decrease the potential for core activation. This can eventually lead to upper limb training or rehabilitative sessions being less effective, which can lead to upper body injuries. This can be useful for the enhancement of knowledge regarding the sequencing of core and upper limb exercises in an athlete's training protocol. Thus, athletes and coaches should consider that exclusive and extensive core training needs to be done after an upper-body training session, not before, and additionally, core exercises should be integrated with upper-body workouts.

Limitations

Only females were recruited for the study. Female athletes from any kind of sports were included in the study.

Muscle groups were studied and not individual muscles; thus, it is not possible to say with certainty which muscle was most responsible for the change.

Exercises in the CSKP were to be performed until voluntary exhaustion and this depended on the individual's level of motivation and hence varied among participants.

The investigator did not have control over other variables, such as interest, attitude, and cooperation, which can be a limitation of the study.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Guru Nanak Dev University (No.: 37/HG, Dated 12/1/2022) and all subjects agreed to take part in the study by signing an informed consent form.

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This paper was extracted from master's thesis of Harsirjan Kaur, approved by the MYAS-GNDU Department of Sports Sciences and Medicine, Guru Nanak Dev University.

Authors' contributions

The both authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interests.

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