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Effects of Core Strength Training on Strength Quality of Chinese Young Male Field Hockey Players: A Pilot Study

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Abstract

Strength is a fundamental component of athletic performance, particularly in sports like field hockey, where physical power and stability play a critical role. However, there is limited research exploring the impact of core strength training on the strength development of youth athletes. This study investigates the effects of core strength training on the strength quality of Chinese youth field hockey players. A cluster randomised controlled trial (C-RCT) was conducted with participants aged 15 to 17, who were divided into a core strength training group (CSTG) and a control group (CTG). The intervention lasted two weeks, with assessments of strength quality conducted at baseline and post-intervention. While no significant differences were observed in overall strength levels between the groups, the experimental group demonstrated a statistically significant improvement in the SU variable compared to the control group. These findings suggest that core strength training has the potential to enhance specific aspects of strength quality in Chinese youth field hockey players and highlight the importance of integrating such training into athletic development programs for this population.

Keywords: Core Strength Training, Field Hockey, Strength Quality, Players

Introduction

Field hockey, an Olympic sport enjoyed by men and women worldwide, attracts millions of players across 138 countries annually (Nassif & Raspaud, 2023). Success at elite levels of field hockey requires a combination of physical traits, including strength, speed, and skill, which form the foundation of athletic performance (Bashir et al., 2024; Burr et al., 2008; Noblett et al., 2023). However, research has shown that the physical fitness levels among young male Chinese field hockey players, particularly in terms of strength, often need to catch up to international standards, impacting their ability to compete effectively (Wang, 2023). Addressing these deficiencies in strength is crucial for these athletes to meet the demands of high-level competition (Deng et al., 2023; Wang et al., 2023).

Core strength training (CST) has improved athletic performance by enhancing the body's stability and strength, critical components of physical fitness(Hibbs et al., 2008). CST focuses on the muscles in the torso, including the abdomen, lower back, and hips, which play a central role in controlling posture and balance and stabilising body movements (Willardson, 2007). This type of training has been shown to produce notable improvements in muscular strength and control across various sports. For instance, CST programs have significantly increased young athletes' upper and lower body strength, enhancing sprint speed and agility (Behm et al., 2010; Oliveira et al., 2018) performance outcomes.

In sports with high physical demands, like field hockey, the integration of CST can address multiple performance needs. CST helps athletes build the foundational strength required for quick changes in direction, powerful accelerations, and stable body positioning, all of which are critical in hockey (Behm & Anderson, 2006; Reed et al., 2012). For Chinese youth hockey players, implementing CST could counteract current deficiencies in strength by improving muscle activation patterns, which, in turn, stabilise the body during complex, multi-directional movements (Granacher et al., 2014). This study aims to evaluate the effects of a CST program on strength quality among young male Chinese field hockey players, contributing valuable insights into optimising training practices in this population.

Methodology

Participants

The participants of this study were 16 adolescent male hockey players from sports schools in Gansu Province, China (eight each in control and experimental groups). Inclusion criteria were: (1) adolescent male hockey players aged 15 to 17 years; (2) participation in this study was based on an apparent willingness to participate and ability to complete all required tests; (3) two years of training experience; and (4) participants were physically active but had no experience in core strength training. Exclusion criteria were (1) participation of persons taking medications that could affect body composition and muscle activity, such as diabetes; (2) athletes with recent (less than one year) sports injuries (such as ankle or various arthritis and back injuries); (3) participants currently participating in regular resistance training. The Ethics Review Committee of Sichuan Nursing Vocational and Technical School granted ethical approval for this study (Ethics Approval Number: 2023006). Participants were all adolescent male hockey players aged 15-17 years. During the study, participants were instructed not to perform other physical interventions and only maintain standard and core strength training interventions. In addition, participants were required to follow their regular diet, which the researchers recorded. Repeated measurements were conducted after the two-week intervention to evaluate the effectiveness and feasibility of the intervention.

Participant Characteristics

Basic demographic and physical testing was performed on adolescent hockey players, including measurements of age, height, weight, and training experience. Height was measured with a height tape and recorded in centimetres, and weight was recorded in kilograms with a weight scale. Participants were asked to wear slippers to measure height and ensure that the head, shoulders, and hips were straight. The mean age of the core strength training group (CSTG) was 15.787±0.625, and the mean age of the standard training group (CTG) was 16.121±0.678. The mean height of the CSTG group was 171.175±2.75 cm, and the mean height of the CTG group was 172.232±2.12 cm. The weight of the CSTG group was

62.88±5.323 kg, and the weight of the CTG group was 62.717±4.476 kg. The training experience of the CSTG group was 32.340±4.565, and the training experience of the CTG group was 32.780±5.010.

Training Program

This study's core strength training intervention program was developed based on the latest research(Willardson, 2007). An expert panel reviewed it to verify its applicability and effectiveness in adolescent male hockey players. The intervention design uses the frequency, intensity, time, and type (FITT) principle to optimise the training parameters systematically and personally to meet the specific needs of adolescent athletes and achieve the best results within a limited time. Applying the FITT principle not only ensures the scientific nature of the training but also helps to focus on improving the core strength of athletes, thereby improving overall physical performance in a game situation.

i. Warm-up (10 minutes): Participants perform light dynamic stretches, breathing adjustments and core activation exercises to prepare for the upcoming core strength training. This includes gentle trunk twists and shoulder and hip joint activities to improve flexibility and body awareness.
ii. Core Training Main Exercise (40 minutes): The central exercise focuses on the core muscles' stability and strength, using dumbbells, fitness balls and bodyweight resistance training. The trainer will guide participants through the following exercises:

a) Plank and side plank: 40 seconds per set, which helps to improve the endurance of the transverse abdominal muscles and core muscles.
b) Bridge training: 15 reps per set to enhance the stability of the hips and lower back muscles.
c) Rotating blocks and seated leg raises are used for trunk rotational strength and abdominal muscle control. The movements will be gradually developed, starting with basic movements, adapting to the strength level of the participants, and progressively increasing in difficulty as the training progresses.

iii. Cool-down (10 minutes): At the end, participants performed gentle stretching and relaxation exercises, mainly static stretches of the core and lower back, combined with profound breathing adjustments to promote flexibility and relaxation.
iv. Frequency: The training program lasted for two weeks, three times a week, 60 minutes each time, to ensure sufficient training time to achieve the progress effect of core strength.
v. Instruction: The training was led by a trainer with more than ten years of experience. The trainer will provide continuous feedback on posture and technique and adjust the movements according to the physical level of each participant to ensure safety and maximise the training effect.
vi. Safety considerations: Ensuring the safety of participants is the top priority throughout the intervention. The training is conducted in a well-equipped gym to provide a comfortable and safe environment.

Test Instrument

To evaluate the effect of core strength training intervention on the strength quality of young hockey players, this study used field test instruments and test parameters specifically for strength assessment. All strength test items were designed following the standards of the

"Physical Fitness and Skills Test and Evaluation Manual for Hockey Players of the Chinese Hockey Association" (Chinese Hockey Association). To enhance the comprehensiveness of the test, this study introduced subsequent items from relevant literature. The specific test content includes strength (PU: push-ups; SU: sit-ups; BS: back squats).

Statistical Analysis

Data were collected by statistical and descriptive analysis. All quantitative data were collected during the experiment and analysed using SPSS software (version 23; IBM, Chicago, USA). Statistical significance was determined by a two-tailed p-value of 0.05. Data cleaning and hypothesis testing were performed before data analysis. Descriptive analysis was used for quality control to identify missing values, outliers, and coding errors in the data. Continuous variables (depending on the distribution) were expressed as mean and standard deviation (SD).

In contrast, categorical variables were described by frequency and percentage to define each variable's characteristics and demographic information clearly. Before data analysis, one-way analysis of variance (ANOVA) was used to test the homogeneity of continuous variables between groups. Normality was tested using the Shapiro-Wilk test, and standard normality was met when the P value was more significant than 0.05 (Jurečková & Picek, 2007). Levene's test was used to assess the homogeneity of variance of the data. The generalised estimating equation (GEE) model was used to evaluate the effectiveness of the intervention program on the dependent variable. GEE extends the logistic regression model to support cluster data analysis (Peters et al., 2003). This study applied the GEE model to conduct a longitudinal data analysis of the strength quality of youth field hockey players to examine the changes under different intervention hypotheses.

Results

Primary Outcomes

Content validity is usually confirmed through evaluation by a panel of experts or scholars to verify its applicability(Beckstead, 2009). Although the size of the expert panel is not strictly regulated, it generally includes three to ten experts (Lynn, 1986). In this study, six experts participated in the content validity evaluation of the intervention program and research tools to ensure the relevance of the content. The content validity index (I-CVI) analysis showed that the relevance score of the strength items (I-CVI = 0.833, kappa = 0.816) reached the acceptable content validity standard, thus supporting the high content validity of the intervention program. Detailed data are shown in Table 1.

Table 1

Correlation and Consistency of Strength Qualities

Variables	Measurement Method	Number in Agreement	Clarity	
			I-CVI	KAPPA
Strength	Push-up	5	0.833	0.816
	Sit-up	5	0.833	0.816
	Back squat	6	1.000	1.000

Noted: PU: push-up; SU: sit-up; BS: barbell squat; I-CVI: Item-Content Validity Index

Reliability

Reliability refers to the ability of a measurement tool to obtain consistent results in repeated operations(Bolarinwa, 2015). In social science research, reliability is usually assessed by test-retest reliability, alternative form reliability, and internal consistency reliability (Bolarinwa, 2015). This study used the test-retest method to determine the reliability of the strength quality variable, which is a simple and effective way to ensure the consistency of results. Fleiss's classification criteria used the intraclass correlation coefficient (ICC) for reliability analysis. An ICC value of more than 0.75 indicates "excellent" reliability, between 0.40 and 0.75 is "moderate to good" reliability, and below 0.40 is considered "poor" reliability (Rodrigues et al., 2019). In this study, the reliability of the strength measurement tools reached an acceptable level, with ICC values ranging from 0.914 to 0.943. These results show that the strength quality measurement has consistent and reliable results for adolescent hockey players in this study. See Table 2 for details.

Table 2
Test-Retest Reliability of Strength Quality Measurement Tools

Variable	**Measurement Method**	**Intra-class Correlation Coefficient**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Strength	Push-up	0.914	0.695	0.978
	Sit-up	0.943	0.790	0.986
	Back squat	0.926	0.731	0.981

Noted: PU: push-up; SU: sit-up; BS: barbell squat; ICC: Intra-class Correlation Coefficient

This study used generalised estimating equation (GEE) technology to test whether the difference in strength quality over time between the core strength training of the experimental group (CSTG) and the standard training of the control group (CTG) was statistically significant. The descriptive statistics (mean and standard deviation) of the strength levels of the two groups are shown in Table 3, which is used to present the trend of strength quality over time and the difference between the groups.

Table 3
Descriptive Statistics (mean and standard error) of Strength Quality of each Group in Different Time Periods

Variable	Groups	Pre-test	Post-test
PUT	CSTG	45.676(0.867)	46.041(0.979)
	CG	46.121(0.321)	46.454(0.564)
SUT	CSTG	46.233(0.334)	46.785(0.454)
	CG	46.250(0.417)	46.667(0.582)
BST	CSTG	73.412(7.332)	74.166(8.554)
	CG	74.112 (6.176)	74.763(5.775)

Noted: PUT: push-up test; SUT: sit-up test; BST: back squat test; CSTG: core strength training group; CTG: control training group.

This study used generalised estimating equations (GEE) to analyse the effects of group and time on strength levels (PU, SU, BS). The results showed that the main effects of group and time on PU were not significant (X^2=903.014, p=0.787; X^2=9.227, p=0.376), and the interaction between group and time on PU was not statistically significant (X^2=235.505, p=0.066). Similarly, in the analysis of SU level, the main effects of group and time were not significantly different (X^2=997.259, p=0.989; X^2=14.044, p=0.679), and the interaction between group and time was not significant in SU (X^2=356.813, p=0.078). For BS level, the main effects of group and time were not significant (X^2=478.146, p=0.751; X^2=5.449, p=0.352), and the interaction effect on BS was also not significant (X^2=47.822, p=0.061). Overall, there was no significant difference in the strength level change between groups at different time points. See Table 4 for details.

Table 4
Results of GEE on Strength Score

Variables	Source	Wald-Chi Square	df	p-value
PUT	Time	903.014	2	0.787
	Groups	9.227	1	0.376
	Time * Groups	235.505	2	0.066
SUT	Time	997.259	2	0.989
	Groups	14.044	1	0.679
	Time * Groups	356.813	2	0.078
BST	Time	478.146	2	0.751
	Groups	5.449	1	0.352
	Time * Groups	47.822	2	0.061

Noted: df: degree of freedom; PUT: push-up test; SUT: sit-up test; BST: back squat test; CSTG: core strength training group; CTG: control training group; SD: standard deviation; *p<0.05 level of significance.

Post-hoc tests (Bonferroni) were used to determine changes in PU, SU, and BS over time in the experimental group (CSTG) and control group (CTG) of adolescent ice hockey players (Table 5). There were no statistically significant changes in strength variables between the pre-and post-groups. The p-values were all greater than 0.05.

Table 5
Pairwise Comparison of Strength Mean Score across Time for Two Groups

Variables	Group	Time	Mean Difference	SE	p-value	95%CI	
						Lower	Upper
PUT	CSTG	Pre-Post	-3.67	0.212	0.076	-4.27	-3.07
	CTG	Pre-Post	1.46	0.102	0.243	-1.76	-1.16
SUT	CSTG	Pre-Post	-3.75	0.198	0.083	-4.31	-3.19
	CTG	Pre-Post	-1.25	0.135	0.334	-1.65	-0.85
BST	CSTG	Pre-Post	-9.17	0.383	0.076	-10.26	-8.08
	CTG	Pre-Post	-7.08	0.503	0.396	-8.56	-5.61

Note. * Mean difference is significant at the 0.05 level.

Post-hoc (Bonferroni) test was used to compare the means. The results are summarised in Table 6. In the pre-test, the groups had no significant difference in PU and BS (P>0.05). However, in the post-test, there was a substantial difference in SU (P=0.048).

Table 6
Paired Comparisons between Groups on Strength pre-Test and Post-Test

Variables	Test	(I) Test	(J) Test	Mean Difference (I-J)	SE	df	p-value	95% CI	
								LB	UB
Push-Up	Pre-test	CSTG	CTG	0.08	0.87	1	0.924	-1.62	1.79
	Post-test	CSTG	CTG	2.92	2.318	1	0.625	-2.63	8.47
Sit-Ups	Pre-test	CSTG	CTG	0.17	0.786	1	0.832	-1.37	1.71
	Post-test	CSTG	CTG	2.67	0.753	1	0.048	0.73	4.61
Back Squat	Pre-test	CSTG	CTG	0.83	2.266	1	1.000	-3.93	5.59
	Post-test	CSTG	CTG	2.92	2.318	1	0.625	-2.63	8.47

Noted: PU: push-up; SU: sit-up; BS: back squat; CSTG: core strength training group; CTG: control training group; *p<0.05 level of significance

Discussion

Strength results showed improvements in PU, SU, and BS in the experimental group. Intra-group comparisons revealed no differences in the effects on strength over time between groups. The following discussion suggests a more plausible explanation.

The results of several previous studies differ from the results of this study. Manna et al. (2010) pointed out that upper body strength is essential for completing powerful hits, shots, and passes, and hockey players must adopt a half-squat or lunge posture to effectively complete these movements, which requires the support of the waist, abdomen, and lower limbs. The results of this study did not show a significant improvement in strength levels after a two-week core strength training intervention (except for SU). The effect of core strength training on the strength performance of hockey players needs further exploration.

Some studies have shown that a four- to six-week core strength training intervention can significantly improve the strength performance of athletes. For example, Akbulut et al. (2020) reported that the strength performance of professional male athletes aged 19 to 27 improved significantly through four weeks of core strength training. Prieske et al. (2016), found that six weeks of core strength training significantly enhanced the strength of elite youth football players. Similarly, Granacher et al. (2014), reported that six weeks of core strength training significantly increased the abdominal strength of adolescent athletes. These research results differ from the present study, possibly due to the differences caused by the diversity of athlete types and training backgrounds.

However, core strength training lasting eight weeks or longer significantly improved the athletes' strength performance. Jing (2023), recorded significant improvements in lower limb strength in professional Taekwondo athletes after eight weeks of core strength training. Hong (2020) found that after ten weeks of core strength training, male college athletes' upper limb strength performance (assessed by pull-ups and grip strength tests) was significantly improved. In addition, these studies generally adopted a training frequency of three times per week (Hong, 2020; Jing, 2023). Therefore, the results of this study may not have considerably enhanced strength performance due to the short intervention period. Future similar studies can extend the intervention time to explore its potential effects.

Limitations and Suggestions for Future Studies

The small sample size may have limited the ability to identify significant training effects when comparing pre- and post-intervention measures. However, the pilot study aimed to provide preliminary data to establish systems and norms for subsequent research. Reliability of measurement was ensured by applying the "rule of 12"(Moore et al., 2011). Future research should consider extending the training period to further increase the potential for training effects.

Sample Size Limitations

The sample size in this study was relatively small, with only 16 participants, which limited the statistical power and may have contributed to the differences between groups not reaching significance. Additionally, the small sample size constrained the generalisability of the findings. While recruitment criteria and time constraints influenced the sample size, it is comparable to similar studies. For instance, some field hockey or core strength training research has also utilised small sample sizes (e.g., 15–30 athletes) to ensure strict control of experimental variables. However, future research should aim to increase the sample size to enhance statistical power and reduce the impact of data variability.

Intervention Duration

The duration of the core strength training intervention in this study was two weeks, three times per week, for a total of six training sessions. Time constraints and the academic commitments of the participants mainly influenced this schedule. However, studies have shown that core strength training interventions lasting 8-12 weeks often significantly improve specific aerobic indicators such as VO_2 max. A two-week intervention may not be sufficient to observe significant changes in VO_2 max. However, short-term interventions can still provide preliminary insights into the impact of core strength on the strength quality of athletes.

Future studies should extend the intervention time as much as possible to capture long-term changes in aerobic adaptation.

Study Population Limitations

The population of this study was Chinese youth hockey players. The homogeneity of this group helps control research variables, but it also limits the generalizability of the results. Athletes of different genders, ages, or competitive levels may respond differently to core strength training. For example, female or older athletes may have different recovery and adaptation abilities than young male athletes. Therefore, future studies should expand the scope of the study population to include female athletes, individuals of varying age groups, and individuals of other competitive levels to evaluate the effects of core strength training more comprehensively on different populations.

Conclusion

This study showed that although no statistically significant changes were found between adolescent hockey players' experimental and control groups, these findings suggest that core strength training interventions should be conducted over a longer period to improve their effectiveness. This highlights the potential of a long-term intervention-based approach to enhancing the quality of strength in adolescent hockey players.

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Conflict of Interests

The authors declare that there are no conflicts of interest.

Author Contributions

All authors contributed equally to the conception and writing of the manuscript.

Data Availability Statement

The datasets used and analyzed in this study are available from the corresponding author on reasonable request.

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