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Review Article

Survey Study of a Division-I Women's Cross-Country Team Reveals Limited Participation in Pre-Collegiate Strength Training: Is There an Opportunity to Improve Training Modalities and Health Outcomes?

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Abstract

Background: While aerobic exercise modalities are the cornerstone cross-country (XC) training, Strength and resistance Training (ST) has become increasingly popular and is widely considered to be beneficial to XC athletes when used appropriately. The purpose of this research was to investigate pre-collegiate participation in various training modalities among a single D-I women's XC team.

Methods and Findings: A questionnaire was distributed to members of Northwestern University's varsity women's XC team. Topics of inquiry included pre-collegiate participation in S&C and ST. Descriptive statistics were produced from the data.

11 female collegiate athletes were surveyed. 36% endorsed having participated in S&C outside of their sports practice. Within the cohort that participated in S&C, 2 endorsed that their S&C involved ST, 3 endorsed anaerobic cardiovascular training and 3 endorsed plyometric training. All 4 in this cohort endorsed that a sports performance professional was involved in their exercise programming.

Conclusion: Despite being amongst the elite in XC, the minority of respondents endorsed having participated in ST prior to college matriculation. Given the prevalence of bone stress injuries in women's XC and the increase in bone mineral density seen with ST, it is necessary to emphasize appropriate resistance training early in an athlete's career and increase its utilization at the high school level.

Keywords: Strength and Resistance Training; Women's Cross-Country; Bone

Abbreviations

BMD: Bone Mineral Density; BSI: Bone Stress Injury; XC: Cross Country; D-I: Division I, vMART: Maximal Anaerobic Running Velocity; VO2max: Maximal Oxygen Consumption; NCAA: National Collegiate Athletic Association; RED-S: Relative Energy Deficiency in Sports; S&C: Strength and Conditioning; ST: Strength and resistance Training

Introduction

Women's cross-country (XC) is a popular sport that consists of middle-distance endurance races. It is estimated that nearly 200,000 high schoolers compete in women's XC annually with over 15,000 competing across all National Collegiate Athletic Association (NCAA) divisions [1,2]. The Division-I (D-I) of the NCAA alone consists of greater than 300 women's XC teams [1]. As with any sport, XC's unique physical stressors yield a characteristic pattern of injury including Bone Stress Injuries (BSI), medial tibial stress syndrome and ankle sprains [3,4]. Several strategies exist to mitigate these injuries including load management and neuromuscular training [5,6].

The core of XC training is centered around optimizing sport-specific cardiovascular efficiency such that high level competitors often log well over 50 miles per week [7,8]. Strength and resistance Training (ST), however, has a less well-defined role in XC [9,10]. ST has both performance and health benefits in the context of XC training, including an association with injury reduction [11,12]. Furthermore, ST has been repeatedly demonstrated to increase Bone Mineral Density (BMD) [13,14]. Given the prevalence of BSIs in XC, these qualities of ST have the potential to support athletes' wellbeing and longevity. While almost all collegiate teams now incorporate some form of resistance training in their protocols, it is unclear whether this has gained traction amongst high school runners who intend to eventually compete at the collegiate level [15,16].

The purpose of this research was to investigate the utilization of Strength and Conditioning (S&C) training prior to undergraduate matriculation in a cohort of current D-1 women's XC athletes. Of particular concern are S&C programming that included ST. Additionally, we intended to study other components of their pre-collegiate training such as use of plyometric, anaerobic and neuromuscular exercises. Our goal in doing so was to gauge whether ST and other training modalities are being adequately utilized prior to participation in elite-level collegiate XC.

Methodology

Participant Recruitment and Survey Administration

The survey was distributed electronically to members of the varsity women's cross-country team at Northwestern University. This study was deemed exempt by the university's Institutional Review Board (IRB) on the grounds that participation was voluntary and survey responses were deidentified. REDCap was used for survey administration and data storage [17,18].

Clinical Design

The survey included both demographic questions and items inquiring about participation in training regimens prior to undergraduate matriculation (Supplemental File). It was specified to these participants that these training regimens must have been performed outside of team or individual sports practices. Included were questions pertaining to training components (ST, plyometrics, etc.), amount of time engaged in training prior to matriculation, average days per week engaged in training, the party responsible for exercise programming (parent, sports coach, sports performance professional, etc.) and setting of training (home gym, training facility, etc.). For questions pertaining to training components, programming and training setting, the respondents were able to endorse multiple answers. In the questionnaire, examples of typical exercises were given for each training modality. For example, strength training was accompanied by the parenthetical "such as squatting, bench pressing, etc." and plyometrics was accompanied by the parenthetical "such as box jumps." Similarly, for the question regarding the party responsible for exercise programming, a sports performance professional was described as "someone who possesses credentials in sports performance/strength and conditioning."

Statistical Analysis

Descriptive statistics were produced based on respondents' answers. All statistical work was done using Microsoft Excel (Microsoft 365, Version 2511).

Results

Of the team's 23 athletes, 11 (48%) responded to our survey (Table 1). The average age of respondents was 20.7 years (range: 19-23). Represented classes included freshman (1), sophomore (4), senior (5) and fifth year (1). 9 endorsed having competed in sports other than XC prior to undergraduate matriculation. All respondents were white, participated in greater than 30 yearly competitions at time of response and spent greater than 8 months per year training for XC prior to matriculation. 36% endorsed having engaged in S&C training prior to undergraduate matriculation (Table 2). Of the 4 who endorsed S&C training, 2 endorsed participating in S&C for 1-2 years prior to matriculation, 1 endorsed 3-4 years of participation and 1 endorsed >4 years. 2 athletes participated in S&C 2 days per week while 2 participated for 3 days per week. All 4 stated that aerobic cardiovascular training was a part of their S&C. 3 endorsed an anaerobic cardiovascular, speed and agility, and/or plyometric component. 2 endorsed strength training. 1 endorsed coordination and neuromuscular training. All 4 of those participating in S&C stated that a sports performance professional was involved in their exercise programming. 2 also endorsed that a sports coach was involved while 1 endorsed that a parent was involved. All 4 of those participating in S&C did so at an athletic training center, while 2 endorsed also training in a home facility and 1 endorsed training in a high school facility.

Total	**11**
Age (avg., (range))	20.7 (19-23)
Year	
Freshman	1
Sophomore	4
Junior	0
Senior	5
Fifth Year	1
Race	
White	11
Yearly Collegiate Competitions	
>30	11
Multisport Participation (Pre-Collegiate)	
Yes	9
No	2
>8 Months/Year Training in XC (Pre-Collegiate)	
Yes	11
No	0

Table 1: Displays baseline characteristics for the study cohort. Age is measured in years. Multisport participation indicates that the athlete quit a sport other than cross country prior to matriculation at their undergraduate institution.

Total	11
Prior S&C†	
Yes	4
No	7
Duration of Participation*	
0-6 months	0
6 months-1 year	0
1-2 years	2
3-4 years	1
>4 years	1
Days Training Per Week*	
1	0
2	2
3	2
4	0
5	0
6	0
7	0
Training Components*	
Strength Training	2
Aerobic Cardiovascular	4
Anaerobic Cardiovascular	3
Speed and Agility	3
Plyometric	3
Coordination/Neuromuscular	1

Other	1
Programmer*	
Athlete	0
Parent/Guardian	1
Sports Coach	2
Sports Performance Professional	4
Other	0
Training Setting*	
Home Facility	2
Commercial Gym	0
High School Facility	1
Athletic Training Center	4
Other	0

Table 2: Details characteristics of respondents' strength and conditioning training prior to undergraduate matriculation. Programmer refers to the person responsible for organizing and planning the training regimen. †Denotes answers are from all respondents. *Denotes answers are only from respondents who endorsed participating in S&C prior to undergraduate matriculation.

Discussion

The hallmark of XC training is high volume running mileage often exceeding 50 miles weekly in elite runners [7,8]. In addition to extensive mileage, ST has become an increasingly utilized adjunctive training modality, especially amongst adult runners engaged in high-level competition [9,10]. Historically, there was sentiment that ST may be maladaptive in distance running should excess skeletal muscle hypertrophy lead to performance detriments [15]. Subsequent research has demonstrated that ST actually confers several performance benefits such as increased time-trial performance, maximal anaerobic running velocity (vMART) and maximal oxygen consumption (VO2max) [15,16]. There is also significant research supporting ST as a protective measure against injury in running and in other athletic endeavors [11,12]. The fact that only 36% of the respondents in our survey endorsed participating in S&C outside of their sports practices and that only 18% endorsed an ST component indicates that a significant proportion of elite high school runners may be forgoing the performance and health benefits conferred by ST.

Among the most notable benefits of ST is its ability to increase Bone Mineral Density (BMD) to the extent that the American College of Sports Medicine (ACSM) recommends resistance training as a means to promote bone health across the lifespan [13,14]. Bone Stress Injuries (BSI) are exceedingly common in women's XC with one study estimating an incidence of 45 BSIs per 100 athlete years [17]. Furthermore, there is a well-studied association between BMD and BSI in both male and female athletes [18-21]. While there is little evidence directly correlating lack of ST with decreased BSI in female XC athletes, any intervention that increases BMD is highly likely to be beneficial. This claim is further supported by the significant evidence showing a dose-dependent inverse relationship between ST and athletic injury risk [11,12]. It should be noted, however, that the benefits of ST are nullified by insufficient nutrition or excessive physical stress such as is seen in the Female Athlete Triad of disordered eating, amenorrhea and osteoporosis [13,22].

Widespread implementation of ST may face several barriers, one of which is financial. All four of the respondents who endorsed pre-collegiate S&C also endorsed that their programming was at least partially done by a sports performance professional. These services are generally rather expensive and may be inaccessible to many athletes [23]. To combat this, high-quality programming may be made more affordable through paid online expert programs where athletes pay a one-time fee or a monthly subscription that is less expensive than in-person training [24]. Downsides to this method, however, include lack of personalized periodization and real-time technical feedback. Yet another less expensive option is procuring training programs for free through platforms like YouTube. This should be done with caution as it can be difficult to verify the credentials of those sharing online material and to assess the quality of that material. It has been cited throughout the literature of several disciplines that information on YouTube is often unreliable and thus athletes attempting to use this platform to inform their training should always check the credentials of the video creator and attempt to assess the veracity of their information [25,26]. A third alternative that solves some of these issues is ST training programs done through the athlete's high school. However, not all high schools offer these and

most analyses studying high school ST programs do not include the school's XC team [27,28]. Furthermore, it is not guaranteed that a high school coach will possess high level sports science credentials.

Risk of overtraining is another important factor to consider when implementing ST. Previous studies have found that at least 50% of high school athletes participate in multiple sports, either within the same season or in separate seasons [29,30]. This is reflected in our study cohort, with 82% of athletes having played a sport other than XC prior to college. Subjecting XC athletes who play multiple high school sports to additional training stressors must be done carefully, as poor implementation may lead to several negative health outcomes including Relative Energy Deficiency in Sport (RED-S). The impacts of RED-S are systemic and include decreased BMD, amenorrhea and cardiovascular dysfunction [31,32]. This condition is of particular concern in XC due to its prevalence in the sport [33]. Therefore, addition of ST on top of the sport-specific workload must be carefully integrated such that it maximizes athletic gains and minimizes injury risk. There may also be psychosocial barriers to implementation and efficacy that must be addressed at both community and individual levels. Body image concerns and eating disorders are prevalent in XC and have the potential to significantly burden an athlete's quality of life [34]. A recent study of 287 female collegiate runners found that 40.8% were at risk for disordered eating [34]. For ST to be safe and effective, an athlete must meet nutritional demands. In the absence of this, ST will likely be detrimental and predispose the athlete to further injury [22,31,32]. Therefore, exceptional care must be taken to ensure that the athlete's metabolic demands are being met when introducing any additional workload. Otherwise, there is significant risk of harming the athlete rather than benefiting them.

Limitations of this study include a small sample size, confinement to a single institution and the potential biases therein. It is certainly possible that there is variability in pre-collegiate ST participation amongst D-I XC teams and this study cannot be assumed to represent participation patterns across all schools. Factors that may influence team-wide levels of pre-collegiate ST participation may include whether the XC program is amongst the elite of the sport and the socioeconomic status of each team's athletes. Since this is a single institution, results cannot be generalized nationally. As such, this work should be considered pilot research that may serve as a catalyst for comprehensive investigation of ST utilization patterns in elite high school XC athletes. Additionally, as with any survey study, the quality of the data depends on the respondents' accurate understanding of the questions, reliable memory and truthful responses.

Strengths of this research include its novelty in that there has been little work done specifically assessing the pre-collegiate participation in S&C by elite-level collegiate XC athletes. The team that was surveyed competes both regionally and nationally amongst the upper echelon of collegiate XC. Because of this, their responses provide a unique glimpse into the pre-collegiate training habits of high-achieving athletes in their sport. Therefore, this data serves as a useful bellwether both for future trends in XC training and as an indicator that there is opportunity to improve current training modalities.

Conclusion

In a survey of Division-I women's cross-country athletes, fewer than 50% of respondents endorsed having participated in an ST regimen outside of their athletics practice prior to undergraduate matriculation. Given the benefits of ST, these findings present an opportunity to further popularize ST as a core aspect of training in elite-level high school XC in a way that may improve the health and performance of future athletes. This implementation, however, must be mindful of certain barriers to access and should be done so in a way that maximizes safety and efficacy. Further research should be done to quantify the utilization of ST amongst elite XC athletes alongside research that investigates the degree to which it may reduce specific injuries that are common to XC.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement
Not applicable.

Ethical Statement
The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement
Informed consent was taken for this study.

Authors' Contributions
All authors contributed equally to this paper.

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