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ORIGINAL ARTICLE

High Number of Daily Steps Recorded by Runners Recovering from Bone Stress Injuries

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Abstract *Background:* Bone stress injuries (BSIs) are common among runners for which activity modification is the primary treatment. The clinical utility of measuring activity during recovery has not been evaluated. *Questions/Purposes:* We sought to measure the physical activity of runners recovering from BSIs and determine if activity can be correlated with symptoms. *Methods:* A prospective observational pilot study was performed of runners with a new lower extremity BSI treated non-surgically. For 30 days, activity of runners was measured with a physical activity tracker and daily pain scores were collected. *Results:* We enrolled 18 runners (average age, 33 years; 72% female). Twelve had stress fractures and six had stress reactions. The average daily steps of all runners during the observation period was 10,018 ± 3232, and the runner with the highest daily steps averaged 15,976. There were similar average daily steps in those with stress fractures versus reactions, 10,329 versus 9965, respectively. There was no correlation between daily steps or relative change in daily steps with pain or relative change in pain scores. *Conclusion:* Runners with BSIs averaged over 10,000 steps per day during early recovery. Clinicians may not be aware of the amount of activity runners maintain after being diagnosed with a BSI. Although daily steps and symptoms could not be correlated in this study, objectively measuring activity may assist clinicians in guiding runners recovering from BSIs.

Level of Evidence: Level 2B, Prospective Cohort Study

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Introduction

Bone stress injuries (BSIs) are common among runners and participants of high-impact exercise and sports [5, 11, 14]. The incidence of BSIs in athletes is highest among female cross-country runners, with 11 per 100,000 athlete exposures in high school and 29 per 100,000 athlete exposures in college [3, 11]. BSIs are also the most frequent injury to prevent would-be first-time marathoners from being able to participate in a race [13]. Multiple risk factors for BSIs have been identified in runners, including females having a higher risk than males and those with a prior history of a BSI [14]. Lower extremity BSIs are suspected when there is gradual onset of pain in the context of high-impact activity or exercise. Radiographs have limited utility for most BSIs and therefore, magnetic resonance imaging (MRI) is often necessary for confirming the diagnosis [15].

With the exception of certain high-risk stress fractures, nonsurgical management is appropriate for most lower extremity BSIs [5, 7, 8]. This includes rest from the causative high-impact activity and correction of risk factors, such as vitamin D and nutritional deficiencies. Depending on the severity of the BSI and associated symptoms, non-weight bearing or partial weight bearing is prescribed to expedite healing and manage symptoms. However, once patients are allowed to fully bear weight, healing may be affected by the amount of low-impact activity during the recovery period. Expert consensus guidelines for returning to running following a BSI advise increasing weekly mileage by no more than 10 to 15% per week, but there are no specific recommendations for acceptable amounts of low-impact activity during the initial recovery period [7].

Physical activity trackers for personal use are common and increasingly seen in medical settings for monitoring functional status in chronic disease and after surgery [1, 4, 6, 9, 10, 12]. Without a more objective measurement of activity, clinicians taking an activity history or prescribing activity restrictions are often limited to estimations, such as the number of blocks or miles walked per day. Since recovery from a lower extremity BSI is dependent in part on limiting weight bearing activity, physical activity trackers may have role in the treatment of BSI.

The primary objective of this study was to measure the activity of runners recovering from BSI with a physical activity tracker and determine if activity can be correlated with symptoms.

Methods

Recreational runners 18 to 50 years of age who were diagnosed with a new lower extremity BSI (stress reaction or stress fracture) by MRI were eligible for the study. Exclusion criteria included having a metabolic bone disorder and undergoing surgical treatment for the BSI. Participants were recruited through the clinical practices of the Primary Sports Medicine Service at Hospital for Special Surgery. Enrollment occurred within 2 weeks of diagnosis by MRI.

There were a total of 18 runners enrolled in this pilot study. The average age was 33 ± 6.7 years and 13 (72%) were female. The majority were white non-Hispanic (14, 78%), followed by white Hispanic (3, 17%) and American Indian/Alaska Native (1, 6%). There were 2 runners with a history of a previous bone stress injury. Menstrual dysfunction was reported by 2 of 13 female runners (15%). Twelve of the 18 runners had stress fractures and six had stress reactions. Ten had BSIs of the tibia, three of the pubic ramus, and one each of the acetabulum, femur, ilium, sacrum, and talus. The average pain by numeric rating scale (NRS) at time of diagnosis was 5.8 ± 2.4. Half (9) of the runners reported experiencing symptoms for more than 4 weeks before being diagnosed with a BSI. Thirteen of the eighteen (72%) runners were training for a race when the injury occurred. The average weekly mileage was 27.6 miles and average number of runs per week was 4.6 when symptoms began. All but two runners participated in other forms of exercise with strength training and biking/spinning being the most common.

Once enrolled, each runner received a FitBit Zip® physical activity tracker (San Francisco, CA, USA) and was instructed to wear it continuously during waking hours for a minimum of 30 days. All patients were provided with standard of care nonsurgical treatment that included a period of rest from running and other weight bearing lower body exercise. No additional guidance was provided regarding goal daily steps. Depending on BSI type and severity, modified weight bearing with crutches and/or a walking boot was prescribed by the treating clinician. For the 4 runners who were prescribed non-weight bearing or partial weight bearing with crutches, physical activity data collection began once the runner was fully weight bearing. Daily surveys were collected throughout the course of recovery on the average and worst pain over the past 24 h as measured by the NRS. Runners were monitored for a minimum of 30 days.

Descriptive statistics were used to analyze the baseline characteristics of the runners and the average daily steps. Unpaired *T* tests were used to compare the average daily steps of runners with stress fractures versus those with stress reactions. Linear regression analysis was used to measure the correlation between daily steps and average pain. Given the exploratory nature of this study, a power analysis was not performed. The study was approved by the Institutional Review Board of Hospital for Special Surgery.

Results

In the first 30 days of data collection, the average daily steps of all runners was 10,018 ± 3232 (Fig. 1). There were similar average daily steps in those with stress fractures versus reactions, 10,329 versus 9965, respectively ($p = 0.92$). Most runners (67%) had at least 1 day with over 15,000 steps. One runner averaged 15,034 steps per day and recorded 25,020 steps in a single day. No participants had yet returned to running within the first 30 days. Pain scores were low for a subset of runners, with four recording no higher than a 2 out of 10 pain on the NRS. During that time, the daily steps average of all participants increased while the average pain decreased (Fig. 1). The response rate for average daily pain during the first 30 days was 93%.

Daily steps could not be correlated with a change in daily pain (percent increased/decreased relative to the prior 7-day average) with $R = 0.036$ (Fig. 2). Similarly, change in daily steps (percent increased/decreased relative to the prior 7-day average) could not be correlated to a change in daily pain with $R = 0.062$ (Fig. 3).

Discussion

Evidence-based activity modification guidelines for runners with bone stress injuries would be valuable to expedite healing and return to running. This study illuminated the activity of runners recovering from BSI. Clinicians may be surprised to see that runners averaged over 10,000 steps per

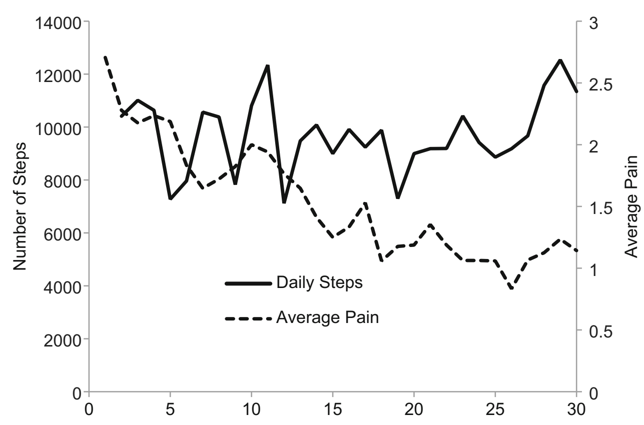

Fig. 1. Average number of steps and average pain over first 30 days.

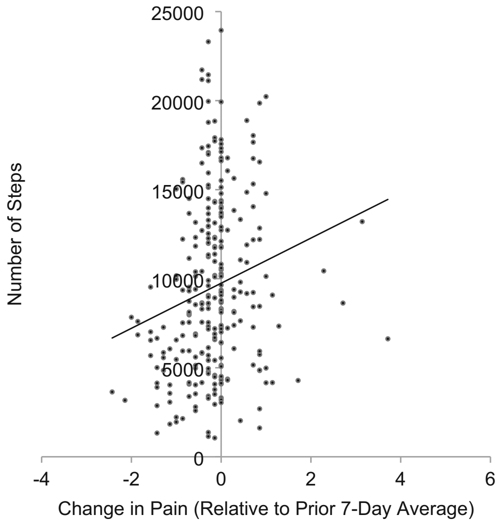

Fig. 2. Change in pain versus number of steps.

day during the rest period of recovery. This is considerably higher than the average American, who averages just over 5000 per day [2]. Some runners in this study had minimal symptoms simply by resting from running regardless of their daily walking steps. In these cases, there was no appreciable correlation between symptoms and activity. However, for runners with persistent symptoms, data from a physical activity monitor may be helpful for clinicians to be able to assess compliance with activity modification recommendations. Although Fig. 1 demonstrates the trends of increasing daily steps and decreasing pain over the course of 30 days, this does not mean that increasing activity will result in decreased pain for an individual runner recovering from a BSI. Our clinical experience is that in the short term, a relative increase in activity can exacerbate symptoms from a BSI. However, as seen in Figs. 2 and 3, short-term relative changes in daily steps and pain could not be correlated in this cohort of runners.

This study was limited by being a small heterogeneous sample of runners with variable symptomatology. Although no association was seen between daily steps and average pain, as an exploratory study, it was not powered to do so. The response rate for the daily symptom survey was high but compliance with wearing the activity tracker could not be verified. Additionally, there was low variability in pain after the first 2 weeks, making it difficult to detect a change relating to activity. The activity data could not account for the effect of differences in the distribution of steps throughout a single day. For example, pain would be expected to be exacerbated if many steps were concentrated to a single event, e.g., a long walk, rather than evenly distributed throughout the day. Selection bias may have affected the results and the subjects in this study may also be more activity than the typical runner with a BSI as it was conducted in New York City where walking is a common means of commuting.

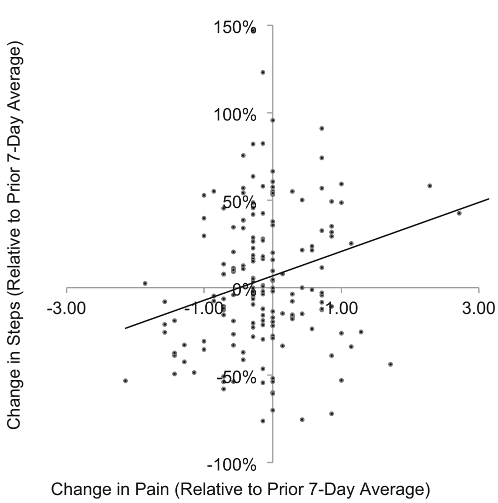

Fig. 3. Change in pain versus change in steps.

Many runners regularly use activity monitors with devices such as smart phones, GPS/smart watches, or physical activity trackers similar to the ones used in this study. Since these technologies have already been adopted by many patients, the data being collected have the potential to avoid prolongation or exacerbations of pain from a BSI if clinicians provide general guidelines for daily steps in the acute phase of a BSI. Further research is needed to better understand which patients and injuries tend to have most correlation between symptoms and physical activity for which providing activity guidelines would be most beneficial. For now, clinicians can use physical activity data in runners recovering from a BSI as a more objective way to prescribe activity modification and measure adherence to recommendations.

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Compliance with Ethical Standards

Conflict of Interest: Brett G. Toresdahl, MD, Marci A. Goolsby, MD, Mark C. Drakos, MD, and Stephen Lyman, PhD, declare that they have no conflicts of interest. Joseph Nguyen, MPH, reports grants outside the submitted work to his institution from the Clinical Translational Science Center (CTSC), National Center for Advancing Translational Sciences (NCATS) grant #UL1- RR024996. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NCATS in Rockville, MD.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent: Informed consent was obtained from all patients for being included in this study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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