DOES FREE MOMENT PREDICT THE INCIDENCE OF TIBIAL STRESS FRACTURE?

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INTRODUCTION

Stress fracture injuries are common in distance runners, and occur most frequently at the tibia. Female runners are twice as susceptible to stress fracture as males. While multiple factors probably lead to the development of stress fractures, biomechanical factors such as loading are considered to play a role. Free moment (FM) is the torsional force about a vertical axis due to friction between the foot and the ground during stance. While FM has been linked to pronation, its potential role in running injuries has not been investigated widely. The relationship of FM to the loads experienced by the lower extremity makes it worthy of further investigation in relation to stress fracture injury. The spiral nature of some stress fractures indicates that torsional stresses on the lower extremity may be involved. If this is the case, the magnitude of the load may be more important than its direction. Furthermore, since FM is calculated directly from a force platform, it may have some value as a simple tool for predicting tibial stress fracture (TSF) in runners.

Preliminary work in our laboratory showed an increase in peak positive FM (resistance to toeing out), and trends towards higher FM at peak braking force and net angular impulse in 13 runners with a history of TSF, compared to runners with no previous lower extremity bony injuries. These trends suggest that there might be significant differences in FM variables between the groups if a larger subject pool were analyzed. Furthermore, the preliminary study did not consider the absolute magnitude of peak FM. An absolute measure (peak regardless of direction) may better represent the size of the torsional force acting on the lower extremity.

The purpose of this study was to investigate the relationships between FM variables and the occurrence of TSF in female distance runners. We hypothesized that maximum positive FM (POSFM), FM at peak braking force (FMBRAK), net angular impulse (IMP) and absolute peak FM (ABSFM) would be greater in runners with a history of TSF compared to uninjured controls. In addition, ABSFM would be predictive of group membership.

METHODS

A group of uninjured female distance runners with a history of tibial stress fracture (n = 25, age = 28 ± 10y, weekly mileage = 116 ± 39 miles) and an age- and mileage-matched control group (n = 25, age = 26 ± 9y, weekly mileage = 117 ± 47 miles) ran at 3.7m/s on a 25m runway containing a force platform sampling at 960Hz. Data from five trials were scaled to body weight and height and values for each variable averaged for statistical analysis. Differences between the TSF and control groups were examined using independent t-tests ($p \leq 0.05$). All t-tests were one-tailed, as only higher values in the TSF group were of interest. The utility of ABSFM in predicting group membership was investigated using binary logistic regression.

RESULTS AND DISCUSSION

Generally, FM was greater in the TSF group (Table 1). While the magnitude of FM was significantly higher in the TSF group for POSFM and FMBRAK, the highest values in both groups were found in ABSFM. ABSFM also had a larger effect size (0.93, large) than POSFM (0.76, moderate). The higher value of ABSFM, compared to POSFM, indicates that in some runners negative FM (resistance to toeing in) is greater in magnitude than positive FM (resistance to toeing out). This is supported by our observations that some runners have a negative bias in their free moment curve. Therefore, POSFM does not always reflect the highest torsional force experienced by these subjects.

Further support for the importance of ABSFM in TSF was provided by the binary logistic regression. Regression results suggest that increased ABSFM is related to an increased likelihood of being in the TSF group. The model indicated that for every 1.0 $x10^{-4}$ increase in ABSFM, the likelihood of having a history of TSF increases by a factor of 1.354 (95% confidence interval 1.086 to 1.688), $p = 0.007$. According to the model chi-square statistic, the model is significant ($p = 0.001$). It also predicted group membership correctly in 66% of the cases. The Nagelkerke R square value was 0.251, suggesting that 25% of the variance between the two groups is explained by ABSFM.

These data suggest a relationship between FM and a history of TSF in distance runners. However, further prospective studies are needed to determine whether ABSFM can be used to predict the occurrence of TSF in female distance runners.

Table 1: Free moment variables in TSF and Control groups.

	POSFM	FMBRAK	IMP (s)	ABSFM
TSF	7.5 ± 4.5	4.0 ± 5.7	6.2 ± 5.7	9.0 ± 4.3
Controls	4.7 ± 2.5	1.6 ± 3.7	1.6 ± 5.5	5.9 ± 2.1
Effect size	0.76	0.49	0.83	0.93
P	0.023	0.043	0.781	0.001

All variables are $x10^{-3}$, except IMP which is $x10^{-4}$.

CONCLUSIONS

Peak positive FM, FM at peak braking force and absolute peak FM were significantly higher in the TSF group. This suggests an association with history of TSF in female distance runners. The magnitude of absolute peak FM successfully predicted a history of TSF in this group in 66% of cases.

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