The effect of neck strength and anthropometric properties of academy football players on the linear and rotational accelerations experienced during heading

Authors

Mr. Phil Bolland[1,2], Dr. Tom Mullen[3], Dr. Nick Dobbin[1]

Affiliation

[1]Sport and Exercise Medicine, Department of Health Professions, Faculty of Health and Education, Manchester Metropolitan University.
[2]Liverpool Football Club. [3]Department of Sport and Exercise Sciences, Manchester Metropolitan University.

N.Dobbin@mmu.ac.uk

01 Introduction

Currently within football, there is a heightened awareness of the potential short- and long-term effects of heading a ball on the player's wellbeing (McKee et al., 2014; Mackay et al., 2019; Pearce et al., 2018). Subsequently, governing bodies have recently introduced rules banning and limiting heading in youth football (The FA, 2022).

Whilst rule changes appear a preferred approach for governing bodies, the extent to which this will impact the long-term wellbeing of players remains unknown. This approach also raises concerns around (i) implementing the rules consistently nationwide, (ii) the reduction in the time allowed for technical development of the skill of heading, and (iii) the reduction in resources that develop physical characteristics that may moderate the risk associated with heading in later years (e.g., neck strengthening programmes).

An alternative approach would be to reduce the risk of sub-concussive forces caused by excessive linear or rotational accelerations experienced when heading. As such, research describing the anthropometric or physical characteristics of players (O'Kane, 2016) and their association with heading during *typical* (i.e., not well-controlled) training environments is warranted.

02 Research Question

Given advances in technology such as fixed-frame dynamometers and instrumented mouthguards that are increasingly used in sport, this study aimed to examine the association between anthropometric and allometrically scaled strength using fixed dynamometry with linear and rotational accelerations measured with an instrumented mouthguard during *typical* football training.

Specifically, we set out to answer:

1. What are the linear and rotational forces experience by academy football players during *typical* football activity?
2. Is neck strength associated with greater or lesser linear and rotational force?
3. Which anthropometric factors are associated with linear and rotational forces experienced during heading?

03 Methodology

Study Design: An observational cohort study design was used. Linear and rotational data was collected from instrumented mouthguards during 13 *typical* field-based training sessions across a 7-week period.

Participants: Eleven football players from a single category one academy (age = 18.2 ± 0.4 years) participated.

Procedures: Anthropometric measurements were recorded before the period of training and included measures (or estimates) of body mass, stature, neck length, neck circumference, head circumference, and head mass. Maximal voluntary isometric neck strength was measured in flexion and extension using the KangaTech. Linear and rotational accelerations were recorded continuously throughout training using a custom fitted instrumented mouthguard (X2 Biosystem).

Analysis: Following inspection of the data, descriptive statistics were generated. Two separate linear mixed models were constructed to assess the relationship between fixed factors and linear and rotational acceleration. Results were converted to an effect size correlation and presented with 95% CI.

Ethics: Ethical approval was granted by the Faculty of Health and Education Research Ethics and Governance Committee at Manchester Metropolitan University (No. 41607).

04 Results

A total of 259 'player-observations' were recorded over the 7-week period, with a mean number of 25 per player across 5 defenders, 4 midfielders and 2 strikers.

The mean and standard deviation (SD) for the linear and rotational accelerations were 11.7 ± 4.1 g and 932.2 ± 679.9 rad/s^2, respectively.

Table 1. Descriptive statistics

Variable	Mean ± SD
Stature (cm)	178.9 ± 5.6
Body mass (kg)	68. 5 ± 6.6
Neck length (cm)	15.7 ± 1.2
Neck circumference (cm)	36.6 ± 1.6
Head circumference (cm)	54.8 ± 3.2
Head mass (kg)	3.2 ± 0.6
Head-neck segment mass (kg)	5.7 ± 0.5
Forward flexion (N)	1.6 ± 0.3
Forward flexion (N/kg$^{0.67}$)	6.6 ± 1.2
Extension (N)	2.7 ± 0.6
Extension (N/kg$^{0.67}$)	10.9 ± 2.4
Right side flexion (N)	2.2 ± 0.5
Right side flexion (N/kg$^{0.67}$)	8.8 ± 1.8
Left side flexion (N)	2.2 ± 0.6
Left side flexion (N/kg$^{0.67}$)	8.9 ± 2.3

Linear Acceleration

There was a trivial to moderate association between neck strength and anthropometric properties with linear acceleration (Figure 1A).

- A one SD increase in neck length and head-neck segment mass reduced linear acceleration by 0.51 and 1.11 g, respectively.
- A one SD increase in neck circumference and head mass increased linear acceleration by 1.10 and 0.20 g, respectively.
- A one SD increase in allometrically scaled forward flexion and extension increased linear acceleration by 0.78 and 0.19 g, respectively. A one SD increase in allometrically scaled side flexion increased linear acceleration by 0.19-0.52 g.

Rotational Acceleration

A small to very large association between neck strength and anthropometric properties was observed with rotational acceleration (Figure 1B).

- A one SD increase in neck length and neck circumference was associated with a lower rotational acceleration by 175.4 and 124.0 rads/s^2, respectively.
- Head mass was positively associated with rotational acceleration (one SD = 132 rads/s^2).
- Forward flexion and extension had a large-to-very large positive association with rotational acceleration (one SD = 140.5 and 185.9 rads/s^2) whilst side flexion had a moderate negative association (166.3 to 233.7 rads/s^2).

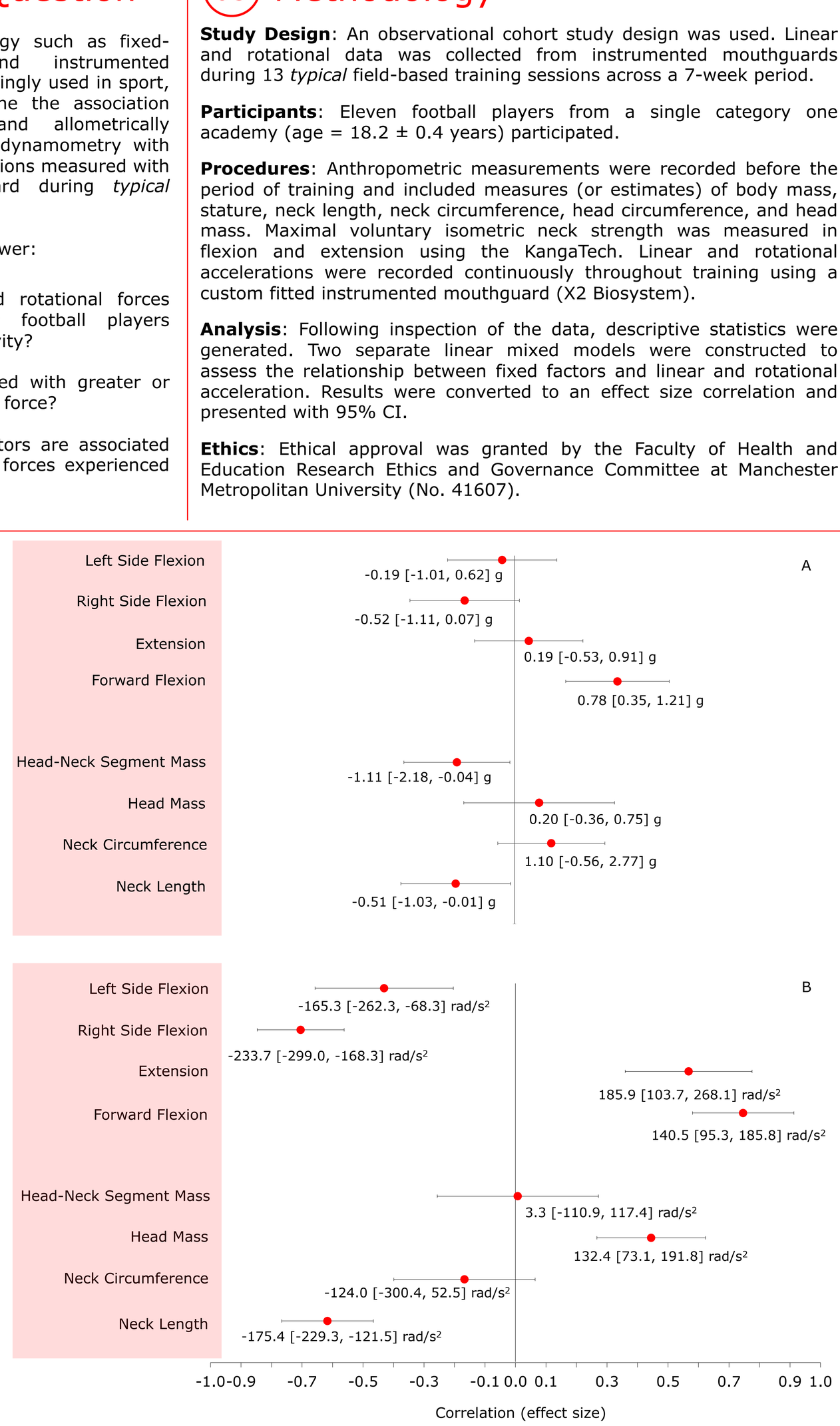

Figure 1. Association between anthropometric and neck strength with linear (A) and rotational (B) acceleration. Numbers below the brackets reflect the change in the intercept (A = 11.9 g, B = 823 rad/s^2) for a one standard deviation change in the fixed factor (Table 1).

05 Conclusion

The findings in this study highlight an association between anthropometric and neck strength properties with linear and rotational accelerations observed during *typical* football activity using robust and valid measures as well as incorporating appropriate scaling methods for strength. These findings could have important implications when managing young athletes returning to heading activity, and when developing individualised neck strengthening programmes. We encourage practitioners working with youth footballers to consider the findings in this study when managing the overall risk, and for researchers to explore the moderating effects of strength, anthropometric properties alongside technical development.

06 References

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