J. Phys. Ther. Sci.
25: 563–566, 2013

Electromyographic Study of Neck Muscle Activity According to Head Position in Rugby Tackles

Koji Morimoto, RPT, MS[1,2)]*, Masaaki Sakamoto, RPT, PhD[2)],
Takashi Fukuhara, RPT, PhD[1)], Kazuo Kato, MD[1)]

[1)] *Asakura Clinic, Seseragi Hospital: 249-1 Asakura-machi, Maebashi, Gunma 371-0081, Japan. TEL: +81 27-265-6522, FAX: +81 27-265-6527*
[2)] *Graduate School of Health Sciences, Gunma University*

Abstract. [Purpose] This study examined differences in neck muscle activity in two different head positions during tackles with the aim of contributing to the prevention of sports injuries. [Subjects] The subjects were 28 male high-school rugby players. [Methods] Two tackle positions were considered: a head-up position and a head-down position. Muscle activities of the sternocleidomastoid muscles and the upper, middle, and lower parts of the trapezius muscles were measured. [Results] Muscle activities of the sternocleidomastoid muscles and the right upper trapezius muscle were significantly increased in the head-up position, and the activity of the lower trapezius was significantly increased in the head-down position. [Conclusion] Tackling with the head-up position increases neck muscle activity and stability of the head and the neck.
Key words: Sternocleidomastoid muscle, Trapezius muscle, Rugby

(This article was submitted Nov. 26, 2012, and was accepted Dec. 25, 2012)

INTRODUCTION

In contact sports such as rugby and American football, head and neck trauma can easily lead to serious injury. The prevention of such injuries is an important part of implementing safety measures. Serious injury in rugby, such as cervical spine injury, often occurs during tackles[1)]. Assuming the head-up position and looking at the opponent is considered to be extremely important in tackles, while the head-down tackle is regarded as a cause of severe cervical spine injury. It has been reported that impacts on the head from the direction of axial compression can cause excessive flexion and injury to the cervical spine[2)].

Previous research on tackles includes measurements using accelerometers[3–5)] and analysis based on video recordings[4, 5)] (for American football), as well as questionnaire surveys[6)] and measurements of the magnitude of the impact on the shoulder (for rugby)[7)]. However, few studies have focused on the activity of neck muscles during tackles.

The aim of this study was to examine the muscle activities of the sternocleidomastoid muscles (SCM) as well as the upper (UT), middle (MT), and lower (LT) trapezius muscles during tackles in the head-up position (HUP) and the head-down position (HDP) both of which are used in rugby.

*To whom correspondence should be addressed.
E-mail: kmorimot@health.gunma-u.ac.jp

SUBJECTS AND METHODS

Subjects

The subjects were 28 young men (mean age 16.3±1.0 years) belonging to a high-school rugby club. The purpose and importance of the study were explained to the person in charge of the rugby club, the subjects, and their parents, and the study was conducted after obtaining their written consent. The study protocol was also approved by The Society of Physical Therapy Science (approval number SPTS2012005).

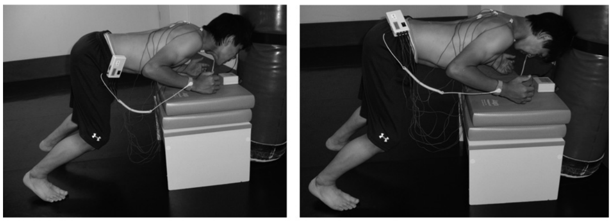
Methods

The activities of the neck muscles were measured in HUP and in HDP during simulated tackles (Fig. 1). In the case of HUP, the hair line in the middle of the forehead was placed in contact with a tackle bag, and in the case of HDP the centriciput was placed in contact with the tackle bag. After this, the tackle posture was maintained with the toes on the ground. In the tackle position, the trunk was horizontal, the physiological anterior curvature of the lumbar spine was maintained, the hip joints were bent at 90°, and the feet were parallel to each other.

The pressure generated at the point of contact between the head and tackle bag while maintaining the tackle position was measured using a hand-held dynamometer (μTas-MF-01, ANIMA Corp., Tokyo, Japan) affixed to the tackle bag. Subjects made contact with the bag with their head and the height of the middle of the thighs from the floor was measured. Subjects were instructed to apply pressure corresponding to half of their body weight (±2 kg) to the sensor while maintaining the tackle position. Muscle activity was measured for 5-s from the beginning of measurement.

Table 1. Positions and resistances used in the measurement of maximal voluntary contraction for each muscle

Muscle	Positions and resistances
Sternocleidomastoid	Resistance applied to forehead with neck flexed in the supine position
Upper trapezius	Resistance applied to distal upper arm in shoulder abduction and superior to shoulder girdle elevation in the sitting position
Middle trapezius	Resistance applied distal to elbow joint in the prone position with 90-degree shoulder abduction and external rotation, and horizontal abduction
Lower trapezius	Resistance applied distal to the elbow joint extended from 125-degree shoulder abduction and external rotation in the prone position



a. Head-up position b. Head-down position

Fig. 1. Tackle positions during measurement

Hip flexion angle was 90°, the physiological anterior curvature of the lumbar spine was maintained, and the trunk was horizontal. A hand-held dynamometer (HHD) sensor was affixed to the tackle bag facing the part of the bag which was in contact with the head. The HHD monitor was placed under the face of the subject, allowing him to keep track of the pressure applied to the head (the part in contact with the bag).

Three measurements were conducted in each position, with a 1-min break between measurements. An AD converter (PowerLab 16/30, ADInstruments Japan, Aichi, Japan) was used to measure the electro-muscular activity. The sampling frequency was 1000 Hz, the range of the band pass filter was 20–500 Hz, and active electrodes were used (FA-DL-141, inter-electrode distance 12 mm, 4assist, Inc., Tokyo, Japan). Before the electrodes were placed, the skin was rubbed with skin preparation gel (skinPure, NIHON KOHDEN CORPORATION, Tokyo, Japan) and then cleaned with alcohol to reduce skin surface impedance. Referring to previous studies, the electrodes for the SCM were attached to the muscle belly, about one-third of the length rostral to the sternal attachment[8, 9]. Electrodes were attached in the direction of the muscle fibers midway between the acromial angle and C7 spinous process for UT[10, 11], midway between the root of the scapular spine and T3 spinous process for MT[10], and midway between the T7 spinous process and the vertebral border of the scapula at the junction of the scapula spine for LT[12]. The earth was attached to the wrist (wrist earth electrode DL-945, S&ME, Tokyo, Japan).

Maximal voluntary contraction (MVC) of each muscle was measured using the positions and resistances shown in Table 1[10, 13–15]. Three 5-s measurements were then taken in each position, with a 1-min break between consecutive measurements.

The obtained electromyograms were processed using biological waveform analysis software (LabChart 7, ADInstruments Japan). The root mean square (RMS) of 3-s stable waveforms extracted from each 5-s task was determined, and the muscle activity data were averaged over the 3 runs. The %MVC value was obtained by normalizing the muscle activity of each muscle in the two tackle postures with MVC.

Table 2. Comparison of muscle activities according to head position

Muscle	Head position	EMG activity normalized by MVC (%)					
		Right			Left		
SCM	HUP	16.2	(20.7)	**	13.3	(21.6)	**
	HDP	4.2	(5.5)		3.1	(6.5)	
UT	HUP	1.8	(5.3)	*	2.2	(4.0)	
	HDP	1.3	(1.8)		1.4	(2.1)	
MT	HUP	4.3	(6.2)		6.5	(7.1)	
	HDP	4.3	(5.5)		5.3	(4.3)	
LT	HUP	12.9	(11.1)	**	11.7	(12.7)	**
	HDP	20.9	(9.7)		19.5	(14.7)	

Median (interquartile range), N=28
*p<0.05, **p<0.001 between HUP and HDP
EMG activity: electromyographic activity
MVC: maximal voluntary contraction
SCM: sternocleidomastoid; UT: upper trapezius; MT: middle trapezius; LT: lower trapezius
HUP: head-up position
HDP: head-down position

Statistical analysis was performed with SPSS ver.19.0 for Windows. Muscle activities in the HUP and HDP were compared using the Wilcoxon signed rank test, with a significance level of 5%.

RESULTS

A comparison of the muscle activities according to head position is shown in Table 2. SCM activity was significantly higher in HUP than in HDP ($p<0.001$). The muscle activity of UT was also significantly higher in HUP than in HDP, but only in relation to the right side ($p=0.02<0.05$); no significant difference was seen for the left UT. MT activity showed no significance difference between the two heads position on either side. Finally, LT activity was significantly higher in HDP than in HUP on both sides ($p<0.001$).

DISCUSSION

Oi et al.[16] constructed a 3D model of the cervical spine and calculated the moment of the cervical muscle group in the mid cervical region. Their results indicate that SCM generates the largest flexor moment with respect to flexion of the cervical region (60% of the total moment). Furthermore, UT generates the largest and the second largest extensor moments within the cervical muscle group at the upper and lower cervical spine levels (37% and 28%, respectively).

In the tackle posture with HUP, activities of the SCM and UT were high. The SCM and UT attach directly to the cervical region and produce large moment arms; therefore, they are considered to be strongly related to the stability of the cervical region. In the tackle posture with HDP, LT activity was high. The LT muscles run along the longitudinal axis and attach to the scapular spine and T5–12 spinous processes, without attaching directly to the cervical region. However, they contribute indirectly to the stability of the cervical region during contact in the HDP tackle by depressing the scapula and pulling UT in the direction of extension. Since MT is a horizontal muscle, it is likely that it does not influence the stability in the directions of flexion and extension.

In the HUP tackle, it can be considered that the activity of the extensor, UT, increased since it extends to the cervical region, while the activity of the flexor, SCM, increased due to extension force received via the forehead. In addition, the stability of the cervical region might have been improved by co-contraction of SCM and UT. Tackling in HUP is recommended from the viewpoint of maintaining a wide visual field and preventing impacts to the cervical region via the centriciput. Previous studies[2] have also pointed out that HUP is important in tackles to prevent cervical spine injury. In the process of tackling, the player normally assumes the head-up position to track the opponent, approaches the opponent, takes a step and hits the opponent with a shoulder. In this, the choice of tackle, which can target the area below the lumbar region or can target the ball (above the lumbar region), depends on the situation. Tackling targeting the area below the lumbar region is effective for stopping the progress of an opponent. In contrast, tackling targeting the ball is performed in cases where it is necessary to prevent the opponent from passing the ball. In this case, the height is above the lumbar region. When the player approaches and hits the opponent with a shoulder, if the player is in the head-down position and the opponent performs an unexpected move (such as moving in the direction of the player's head), there is a chance that the head of the player can come in contact with a knee or the abdomen of the opponent. Considering the points raised in the discussion above, it is likely that HUP improves the stability of the cervical region and contributes to the prevention of severe accidents such as cervical spine injury resulting from impacts via the head. To learn how to perform tackling in HUP, it is important that players begin their training using a stationary object, such as a tackling dummy, followed by the gradual introduction of tackling an actual opponent and training for tackling in response to the current situation. Furthermore, while training the upper parts of the trapezius muscles is regarded as important, emphasis should also be placed on training the lower parts of the trapezius muscles in order to account for cases where tackling is performed in HDP.

In HDP the stability of the cervical region is maintained through bones and ligaments; therefore SCM and UT activities were relatively low. Among the cervical spine injuries received in tackles, there is a high incidence of injury from excessive flexion caused by compressive axial stress from the direction of the centriciput[17, 18]. In order to prevent severe accidents, it is extremely important to avoid impacts via the centriciput. However, such impacts might occur under unforeseen circumstances, such as a player being fatigued or when he cannot predict the movement of the ball carrier. In the present study, LT activity increased during contact in HDP, which suggests the possibility that the stability of the neck region can be increased by strengthening LT.

The limitations of this study include the small number of cases considered, that the study was conducted with a single rugby team, and that a static tackle position was used rather than studying tackles with actual impacts on the head and the neck. In addition, this was a cross-sectional study. It is necessary to conduct further studies by investigating the differences in muscle activities when performing training of the neck muscles. We plan to continue this research by investigating safer training methods for mastering tackles.

REFERENCES

1) MacLean JG, Hutchison JD: Serious neck injuries in U19 rugby union players: an audit of admissions to spinal injury units in Great Britain and Ireland. Br J Sports Med, 2012, 46: 591–594. [Medline] [CrossRef]
2) Heck JF, Clarke KS, Peterson TR, et al.: National athletic trainers' association position statement: head-down contact and spearing in tackle football. J Athl Train, 2004, 39: 101–111. [Medline]
3) Duma SM, Manoogian SJ, Bussone WR, et al.: Analysis of real-time head accelerations in collegiate football players. Clin J Sport Med, 2005, 15: 3–8. [Medline] [CrossRef]
4) Pellman EJ, Viano DC, Tucker AM, et al.: Concussion in professional football: location and direction of helmet impacts − part 2. Neurosurgery, 2003, 53: 1328–1340. [Medline] [CrossRef]
5) Viano DC, Pellman EJ, Tucker AM, et al.: Neurosurgery. Concussion in professional football: biomechanics of the striking player − part 8. Neurosurgery, 2005, 56: 266–280. [Medline] [CrossRef]
6) Garraway WM, Lee AJ, Macleod DA, et al.: Factors influencing tackle injuries in rugby union football. Br J Sports Med, 1999, 33: 37–41. [Medline] [CrossRef]
7) Usman J, McIntosh AS, Fréchède B: An investigation of shoulder forces in active shoulder tackles in rugby union football. J Sci Med Sport, 2011, 14: 547–552. [Medline] [CrossRef]
8) Sommerich CM, Joines SM, Hermans V, et al.: Use of surface electromyography to estimate neck muscle activity. J Electromyogr Kinesiol, 2000, 10: 377–398. [Medline] [CrossRef]
9) Keshner EA, Campbell D, Katz RT, et al.: Neck muscle activation patterns in humans during isometric head stabilization. Exp Brain Res, 1989, 75: 335–344. [Medline] [CrossRef]
10) Cools AM, Dewitte V, Lanszweert F, et al.: Rehabilitation of scapular muscle balance: which exercises to prescribe? Am J Sports Med, 2007, 35: 1744–1751. [Medline] [CrossRef]
11) Jackson JA, Mathiassen SE, Dempsey PG, et al.: Methodological variance associated with normalization of occupational upper trapezius EMG using sub-maximal reference contractions. J Electromyogr Kinesiol, 2009, 19: 416–427. [Medline] [CrossRef]
12) Ebaugh DD, Spinelli BA: Scapulothoracic motion and muscle activity dur-

ing the raising and lowering phases of an overhead reaching task. J Electromyogr Kinesiol, 2010, 20: 199–205. [Medline] [CrossRef]
13) Hislop HJ, Montgomery J: Daniels and Worthingham's Muscle Testing; Techniques of Manual Examination. 7th ed. Philadelphia: WB Saunders, 1995, p 28.
14) Tucker WS, Campbell BM, Swartz EE, et al.: Electromyography of 3 scapular muscles: a comparative analysis of the cuff link device and a standard push-up. J Athl Train, 2008, 43: 464–469. [Medline] [CrossRef]
15) Tucker WS, Armstrong CW, Gribble PA, et al.: Scapular muscle activity in overhead athletes with symptoms of secondary shoulder impingement during closed chain exercises. Arch Phys Med Rehabil, 2010, 91: 550–556. [Medline] [CrossRef]
16) Oi N, Pandy MG, Nightingale RW, et al.: Variation of neck muscle strength along the human cervical spine. Stapp Car Crash J, 2004, 48: 397–417. [Medline]
17) Shelly MJ, Butler JS, Timlin M, et al.: Spinal injuries in Irish rugby: a ten-year review. J Bone Joint Surg Br, 2006, 88: 771–775. [Medline] [CrossRef]
18) Kuster D, Gibson A, Abboud R, et al.: Mechanisms of cervical spine injury in rugby union: a systematic review of the literature. Br J Sports Med, 2012, 46: 550–554. [Medline] [CrossRef]