ORIGINAL ARTICLE

Effect of incorporating low intensity exercise into the recovery period after a rugby match

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Background: The psychological and physiological condition of athletes affect both their performance in competitions and their health. Rugby is an intense sport which appears to impose psychological and physiological stress on players. However, there have been few studies of the most appropriate resting techniques to deliver effective recovery from a match.
Objectives: To compare the difference in recovery after a match using resting techniques with or without exercise.
Methods: Fifteen Japanese college rugby football players were studied. Seven performed only normal daily activities and eight performed additional low intensity exercise during the post-match rest period. Players were examined just before and immediately after the match and one and two days after the match. Blood biochemistry and two neutrophil functions, phagocytic activity and oxidative burst, were measured to assess physiological condition, and the profile of mood states (POMS) scores were examined to evaluate psychological condition.
Results: Immediately after the match, muscle damage, decreases in neutrophil functions, and mental fatigue were observed in both groups. Muscle damage and neutrophil functions recovered with time almost equally in the two groups, but the POMS scores were significantly decreased only in subjects in the low intensity exercise group.
Conclusions: Rugby matches impose both physiological and psychological stress on players. The addition of low intensity exercise to the rest period did not adversely affect physiological recovery and had a significantly beneficial effect on psychological recovery by enhancing relaxation.

Rugby is an intense sport, consisting of both running play and contact play. Playing rugby appears to impose both psychological and physiological stress on the players. In fact, the incidence of injury during a rugby match is high compared with other sports.[1–3] Some studies have shown that intense exercise also affects the immune system and injures muscle tissue. The incidence of upper respiratory tract infection among endurance athletes is apparently high.[4] Major retardation of neutrophil functions has been shown in footballers during the training season, which may partly explain the susceptibility to infection in elite athletes.[5] In addition, several studies have examined the relation between exercise and psychological condition, concluding that intense exercise adversely affects mood states,[6 7] and may even decrease competitive performance.[8] Adequate rest after intense exercise may therefore be important to enhance both physiological and psychological recovery.

Of the several patterns of rest used for athletes after competitions, two main ones have emerged. One method is to encourage participants to take it easy and only go about their everyday business during the rest period. The alternative method advocates the addition of low intensity exercise. There is, however, insufficient scientific evidence to determine which is the more effective for rugby players after a match. The aim of this study was thus to investigate differences in the psychological and physiological recovery in two groups of rugby players who followed one or other of the above regimens.

METHODS

Subjects and study protocol

The subjects were 15 Japanese rugby footballers who belonged to one of the top Japanese collegiate rugby football teams. All subjects played rugby for 80 minutes with an interval of 10 minutes, and their team won the match 52 to 12. We randomly classified the 15 subjects into two groups to follow the two different rest regimens. Seven subjects (four forwards and three backs) went about their normal daily life without any exercise; they comprised the complete rest group. Eight subjects (four forwards and four backs) performed low intensity exercise in water during the rest period; they comprised the active rest group. The one hour session of aquatic exercise consisted of 50 m of slow breaststroke, 100 m of walking gently forwards, 50 m of running gently backwards, and 50 m of gentle side stepping, once a day.

Subjects were studied in the morning of the day of the match, within 10 minutes of finishing the match, and in the mornings of days 1 and 2 after the match. Both psychological and physiological state were examined. As indicators of physiological condition, blood biochemistry and neutrophil functions were examined, particularly as the latter are recognised markers of physiological stress in sports science.[9–11] To evaluate psychological condition, profile of mood states (POMS) scores were used.[12] Approval was obtained from the ethics committee of the Hirosaki University School of Medicine. After the study protocol and purpose had been explained, written consent was obtained from all subjects before the study.

Abbreviations: CK, creatine kinase; FITC, fluorescein isothiocyanate; FITC-OZ, FITC labelled opsonised zymosan; GOT, glutamate oxaloacetate transaminase; GPT, glutamate pyruvate transaminase; LDH, lactate dehydrogenase; POMS, profile of mood states

Blood biochemistry

Total leucocyte and neutrophil counts are increased by acute exercise[13] and decrease after exercise,[14–16] as observed in this study. Some researchers have reported that these increases contribute to muscle tissue repair,[17] whereas others have reported that they are related to inflammation of muscle tissue.[18] Glutamate oxaloacetate transaminase (GOT), glutamate pyruvate transaminase (GPT), creatine kinase (CK), and lactate dehydrogenase (LDH) are myocyte enzymes that are released into the circulation when muscle injury has occurred, including exercise related insults.[19–21] The quantified increase in the plasma activities of these enzymes can indicate the degree of muscle damage.[22 23]

A 10 ml blood sample was taken from a forearm vein of seated subjects. Total leucocyte and neutrophil counts were measured using an automatic cell counter. The serum levels of GOT, GPT, CK, and LDH were also measured.

Assays of neutrophil oxidative burst/phagocytosis

Neutrophils play an important role in the immune system, forming the first line of defence against invading microorganisms[24] by phagocytosis and production of reactive oxygen species.[25] A number of studies have investigated the effects of exercise on neutrophil functions in athletes, and the results suggest that there is a decrease in phagocytic activity after strenuous endurance exercise.[13] Thus, measuring neutrophil functions after exercise can indicate the intensity of the exercise.

Neutrophil oxidative burst and phagocytic activities were measured by two colour flow cytometry. To measure the oxidative burst, hydroethidine (44.4 μM; Polyscience Inc, Warrington, Philadelphia, USA) was used as an indicator of the generation of oxygen free radicals. Opsonised zymosan particles labelled with fluorescein isothiocyanate (FITC; Sigma Chemical Co, St Louis, Missouri, USA) were used as an indicator to measure phagocytic activities. In brief, heparinised whole blood samples (100 μl) were mixed with hydroethidine (final concentration 8 μM). After incubation at 37℃ for five minutes, the samples were added to 30.5 μl FITC labelled opsonised zymosan (FITC-OZ; final concentration 1 mg/ml), and incubated at 37℃ for 40 minutes. Lyse and Fix 10 Test (Immunotech, Marseille, France) was added to lyse red blood cells and fix the samples. The samples were washed twice in phosphate buffered saline with sodium azide before flow cytometry. To measure the oxidative burst activities, neutrophils in 100 μl hydroethidine labelled whole blood without FITC-OZ were prepared as the baseline control. The samples were mixed with 50 μl paraformaldehyde (50 mg/ml; Wako Pure Chemical Industries, Ltd, Osaka, Japan) and kept shaded and cool for two days. Just before flow cytometry, Trypan blue (final concentration 0.25 mg/ml; Sigma) was added to differentiate between attached and ingested FITC-OZ using the fluorescence quenching method.[26 27]

Flow cytometry assay

Samples were analysed by flow cytometry (FACScan; Becton Dickinson, San Jose, California, USA) using CaliBRITE Beads (Becton Dickinson) as a control. For each sample, 10 000 neutrophils were analysed. The mean channel number of fluorescence intensity of activated neutrophils was used as the index of oxidative burst and phagocytic activity. The percentage of positive cells was counted to express the rate of neutrophils producing reactive oxygen species or incorporating opsonised zymosan. We calculated the cumulative fluorescence intensity by multiplying fluorescence intensity by the ratio of positive cells. Cumulative fluorescence intensity was used as the quantitative index of total oxidative burst and total phagocytic activity.

POMS assay

To evaluate the psychological condition of the subjects, we used POMS scores,[12] which can assess the overall mood of a subject. There are six factors: tension, depression, anger, vigor, fatigue, and confusion. It is a quick and easy method of assessing the psychological condition of athletes.[5 6]

Statistical analysis

The results of each measurement are presented as mean (SD). Differences in biochemistry, neutrophil functions, and POMS score at four time points (before, immediately after, one day after, and two days after the rugby match) were analysed by the Dunett test. Differences were considered to be significant at $p<0.05$.

RESULTS

Table 1 shows changes in total leucocyte and neutrophil counts after the rugby match. In both groups, total leucocyte count was significantly increased immediately after the match and so was the neutrophil count ($p<0.01$). However, one day after the match, the neutrophil count had returned to the pre-match value. There were no differences in neutrophil counts between the two groups at any time points.

Table 2 shows the changes in serum enzyme activities after the rugby match. In both groups, GOT activity was increased immediately after the match and then decreased over time. Two days after the match, it was significantly lower than immediately after the match in both groups. In contrast, GPT activity did not change significantly. There were no differences in GOT or GPT activities between the groups throughout the experimental period. In both groups, CK activity had significantly increased immediately after the match ($p<0.05$), and the increase was most apparent one day after ($p<0.05$). Decreased CK activity was observed two days after the match even in the active rest group. Changes in LDH activity were similar to those of CK, and there were no significant differences between the two groups throughout the experimental period.

Tables 3 and 4 show neutrophil phagocytic activity and oxidative burst activity respectively before and after the rugby

Table 1 Changes in blood leucocyte and neutrophil counts after a rugby match

	Total leucocytes (/μl)		Neutrophils (/μl)	
	Complete rest	Active rest	Complete rest	Active rest
Before	6700.0 (750.6)**	6350.0 (680.3)**	3021.4 (829.4)**	2448.3 (358.3)**
After	10971.4 (2330.7)	10075.0 (2738.0)	8151.1 (3280.1)	7080.1 (2499.5)
1 day after	8585.7 (807.1)**	8012.5 (2088.4)*	4583.0 (1288.2)**	3485.5 (960.8)**
2 days after	7042.9 (1144.3)**	6750.0 (1088.9)*	3273.1 (1169.5)**	3141.7 (744.1)**

Results are expressed as mean (SD). After the match players either relaxed completely (complete rest group) or incorporated some exercise into their relaxation (active rest group).
*$p<0.05$, **$p<0.01$ compared with the value immediately after the match.

Table 2 Changes in the activity of serum enzymes after a rugby match

	Enzyme activity (U/l)	
	Complete rest	Active rest
GOT		
Before	27.7 (12.5)	23.5 (3.0)*
After	30.6 (14.6)	28.8 (6.1)
1 day after	28.7 (14.1)	29.4 (5.8)
2 days after	22.6 (9.0)*	24.0 (6.4)*
GPT		
Before	25.0 (9.1)	22.0 (6.5)
After	26.4 (9.1)	22.5 (8.0)
1 day after	24.3 (8.2)	22.6 (7.0)
2 days after	22.9 (8.1)	20.8 (6.0)*
CK		
Before	414.3 (429.1)*	351.6 (131.6)*
After	489.0 (454.2)	474.3 (177.7)
1 day after	636.9 (542.5)*	715.4 (438.3)*
2 days after	355.4 (256.8)*	448.5 (260.9)
LDH		
Before	465.6 (102.9)*	410.3 (43.2)**
After	572.9 (160.0)	519.0 (79.2)
1 day after	480.3 (126.6	479.6 (100.8)
2 days after	405.3 (89.5)**	380.3 (46.4)*

Results are expressed as mean (SD). After the match players either relaxed completely (complete rest group) or incorporated some exercise into their relaxation (active rest group).
*$p<0.05$, **$p<0.01$ compared with the value immediately after the match.

match. Phagocytic activity per cell and total phagocytic activity had decreased one day after the match in both groups ($p<0.01$). However, only in the complete rest group was a significant decrease in phagocytic activity still apparent two days after the match ($p<0.05$). In both groups, the rate of production of reactive oxygen species was higher immediately after the match. The high ratio persisted two days after the match in both groups. Oxidative burst activity per cell and total oxidative burst activity had decreased at the end of match ($p<0.01$). However, in both groups, they recovered over time. Two days after the match, total oxidative burst activity was higher than immediately after the match in both groups. The recovery of total oxidative burst activity was not affected by performing exercise during the rest period.

Table 3 Neutrophil phagocytic activity in rugby players before and after a match

	Complete rest	Active rest
Phagocytic rate (%)		
Before	97.6 (0.6)	96.1 (3.4)
After	96.8 (1.8)	97.4 (1.1)
1 day after	95.9 (1.7)	95.1 (3.7)
2 days after	95.4 (1.5)	96.1 (1.6)
Phagocytic activity per cell		
Before	440.9 (48.8)	443.7 (57.6)
After	417.3 (62.0)	403.7 (58.4)
1 day after	318.4 (24.8)**	324.8 (48.2)**
2 days after	343.6 (75.0)*	358.6 (53.1)
Total phagocytic activity		
Before	430.0 (46.3)	427.0 (63.1)
After	404.4 (63.4)	393.7 (59.9)
1 day after	305.2 (22.7)**	308.5 (45.7)**
2 days after	327.4 (68.0)*	344.7 (52.6)

Results are expressed as mean (SD). After the match players either relaxed completely (complete rest group) or incorporated some exercise into their relaxation (active rest group).
$p<0.05$, **$p<0.01$ compared with the value immediately after the match.

Table 4 Neutrophil oxidative burst activity in rugby players before and after a match

	Complete rest	Active rest
Oxidative burst rate (%)		
Before	94.5 (1.5)*	91.9 (2.7)**
After	97.7 (1.4)	97.0 (2.3)
1 day after	95.9 (4.1)	93.9 (5.8)
2 days after	97.7 (3.4)	98.4 (1.0)
Oxidative burst activity per cell		
Before	296.3 (36.7)**	299.8 (28.0)**
After	217.2 (27.0)	229.2 (34.0)
1 day after	251.6 (16.0)	240.1 (44.2)
2 days after	300.9 (43.5)**	312.1 (39.4)**
Total oxidative burst activity		
Before	279.9 (34.2)**	276.2 (31.6)**
After	211.9 (24.0)	221.9 (30.3)
1 day after	241.4 (21.2)	227.6 (52.5)
2 days after	294.2 (45.1)**	307.2 (38.4)**

Results are expressed as mean (SD). After the match players either relaxed completely (complete rest group) or incorporated some exercise into their relaxation (active rest group).
$p<0.05$, **$p<0.01$ compared with the value immediately after the match.

Table 5 shows the changes in POMS after the rugby match. Depression and fatigue scores were increased immediately after the match in both groups, and there were no significant differences between the two groups. The tension score had not changed immediately after the match, but the decrease in the tension score at two days after the match was significant only in the active rest group. Anger and vigor scores did not change significantly during the study period in either group.

Table 5 Changes in POMS scores after a rugby match

	Complete rest	Active rest
Anger		
Before	6.4 (6.1)	5.4 (6.7)
After	4.6 (3.8)	11.6 (14.2)
1 day after	3.6 (4.4)	5.6 (8.7)
2 days after	4.7 (7.1)	5.0 (8.5)
Confusion		
Before	6.9 (3.8)	6.0 (3.4)
After	7.9 (4.2)	10.3 (6.7)
1 day after	6.6 (3.7)	5.6 (3.7)
2 days after	6.1 (2.9)	4.6 (2.4)
Depression		
Before	6.1 (7.9)	7.4 (8.3)
After	11.6 (7.8)	12.5 (11.7)
1 day after	8.7 (10.1)	7.0 (12.6)
2 days after	7.9 (6.9)	5.9 (8.0)
Fatigue		
Before	7.3 (7.1)*	11.3 (6.7)*
After	13.4 (7.1)	20.1 (5.7)
1 day after	9.1 (5.6)	15.1 (7.4)
2 days after	8.3 (7.6)	12.6 (10.1)
Tension		
Before	9.0 (4.8)	11.0 (5.3)
After	8.9 (4.6)	10.3 (6.3)
1 day after	6.3 (5.8)	7.3 (5.5)
2 days after	6.4 (3.0)	5.5 (3.2)*
Vigor		
Before	14.6 (7.6)	13.0 (6.0)
After	12.4 (6.8)	10.3 (7.1)
1 day after	7.9 (4.3)	9.1 (6.8)
2 days after	8.6 (6.1)	10.3 (7.3)

Results are expressed as mean (SD). After the match players either relaxed completely (complete rest group) or incorporated some exercise into their relaxation (active rest group).
*$p<0.05$ compared with the value immediately after the match.

DISCUSSION

This study has four major limitations. The first is that the sample is small (n = 15) and heterogeneous, because the game of rugby is very different for players in different positions. As the sample size was small, the subjects in the two groups could not be subdivided into backs and forwards to compare them with each other. The second limitation is that only the results of one game were recorded, and the subjects were on the winning rather than the losing team. If we had examined the subjects after a losing match, we may have seen a different result. The third limitation is that the observation period (one day) is too short. A longer period is needed (for example one week) to evaluate the effect of the two types of rest in detail. The fourth limitation is that we do not have any data on the level of intensity of the exercise in this match.

Usually, muscle tissues recover during rest, and the duration of recovery depends on the intensity of the preceding exercise.[28] In this study, there were no differences between the two groups with respect to the activities of GOT, GPT, CK, and LDH in the serum (indicative of the damage/recovery of muscle tissues) during the one or two days after the match. This indicates that the load of low intensity exercise in the active rest group did not affect recovery of the muscle tissue.

Neutrophil functions, including phagocytic activity and oxidative burst activity, have received much attention as being good markers for physiological stress.[9–11] Many reports have examined the effects of exercise on neutrophil functions in athletes. Neutrophil phagocytosis remains unchanged or increases after single bouts of various kinds of exercise,[29–31] and a decrease in neutrophil phagocytic activity in the nasal mucosa has been observed after long distance running.[32] Furthermore, strenuous endurance exercise induces a decrease in neutrophil phagocytosis per cell.[33] On the other hand, increased neutrophil oxidative burst activity has been shown in athletes after exercise.[34] It is also increased during the sports season in basketball players.[35] In male judoists, oxidative burst activity is increased by intense exercise but not affected by energy restriction.[11]

In this study, exercise in a rugby match decreased neutrophil phagocytic activity immediately after the match. The results indicate that competitive rugby is an intense form of exercise, generating enough stress to modulate neutrophil functions. Recovery of these functions was observed in both sets of subjects with and without exercise during rest two days after the competition, even though they had not recovered to their previous values. Furthermore, the degree of recovery of neutrophil functions was the same in the two groups. These results may suggest that two days of rest was not enough to allow full recovery of neutrophil functions after a rugby match, which consists of prolonged intense exercise resulting in muscle damage, and the addition of low intensity exercise to the rest period did not impair the physiological recovery of neutrophil function.

Psychological condition was modulated after the rugby match. Psychological stress in a rugby match is probably due not only to the intensity of the exercise, but also to the players' satisfaction with their own performances. Therefore in this study the players' psychological states may have been affected by the fact that they won the match. We might have seen a completely different picture had they lost. Thus future studies should average the results of a series of matches.

Psychological recovery was observed over time in both the groups. However, a decreased POMS tension score was significant in only the subjects whose rest incorporated low intensity exercise. This result is in accordance with previous findings, that moderate exercise enhances relaxation and decreases psychological stress.[36] Therefore incorporating low intensity exercise into the rest period after a rugby match may achieve better psychological recovery in the players.

In conclusion, the results of this study indicate that performing some exercise during the rest period after a match may promote better psychological recovery in rugby players, without impairing their physiological recovery. Future studies should address the recognised limitations of this study, including the single match problem, the position related question, and the length of the assessment period. These results, however, indicate that further study is warranted to address and determine the optimum quantity and quality of exercise during the rest period for rugby players and indeed participants in other sports.

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REFERENCES

1 **Gissane C**, Jennings D, Kerr K, *et al.* A pooled data analysis of injury incidence in rugby league football. *Sports Med* 2002;**32**(3):211–6.
2 **Lee AJ**, Garraway WM. Epidemiological comparison of injuries in school and senior club rugby. *Br J Sports Med* 1996;**30**(3):213–7.
3 **Garraway M**, Macleod D. Epidemiology of rugby football injuries. *Lancet* 1995;**345**(8963):1485–7.
4 **Mackinnon LT**. Chronic exercise training effects on immune function. *Med Sci Sports Exerc* 2000;**32**:369–76.
5 **Bury T**, Marechal R, Mahieu P, *et al.* Immunological status of competitive football players during the training season. *Int J Sports Med* 1998;**19**(5):364–8.
6 **Raglin JS**, Morgan WP, O'Connor PJ. Changes in mood states during training in female and male college swimmers. *Int J Sports Med* 1991;**12**:585–9.
7 **Speechly DP**, Taylor SR, Rogers GG. Differences in ultra-endurance exercise performance-matched male and female runners. *Med Sci Sports Exer* 1996;**28**:359–65.
8 **Raglin JS**. Psychological factors in sport performance: the Mental Health Model revisited. *Sports Med* 2001;**31**:875–90.
9 **Suzuki K**, Nakaji S, Yamada M, *et al.* Impact of a competitive marathon race on systemic cytokine and neutrophil responses. *Med Sci Sports Exerc* 2003;**35**(2):348–55.
10 **Yamada M**, Suzuki K, Kudo S, *et al.* Raised plasma G-CSF and IL-6 after exercise may play a role in neutrophil mobilization into the circulation. *J Appl Physiol* 2002;**92**(5):1789–94.
11 **Kowatari K**, Umeda T, Shimoyama T, *et al.* Exercise training and energy restriction decrease neutrophil phagocytic activity in judoists. *Med Sci Sports Exerc* 2001;**33**(4):519–24.
12 **McNair DM**, Losr M, Droppleman LF. Profile of mood states manual. SanDiego CA: Educational and Industrial Testing Service, 1971.
13 **Nielsen HB**, Secher NH, Kappel M, *et al.* Lymphocyte, NK, LAK cell response to maximal exercise. *Int J Sports Med* 1996;**17**:60–5.
14 **Peters EM**, Bateman E, eds. Ultramarathon running and upper respiratory tract infections. *S Afr Med J* 1983;**64**:582–4.
15 **Müns G**. Effect of long-distance running on polymorphonuclear neutrophil phagocytic function of the upper airways. *Int J Sports Med* 1994;**15**:96–9.
16 **Gabriel H**, Muller HJ, Kettler K, *et al.* Increased phagocytic capacity of the blood, but decreased phagocytic activity per individual circulating neutrophil after an ultradistance run. *Eur J Appl Physiol* 1995;**71**:281–4.
17 **Fielding RA**, Manfredi TJ, Ding W, *et al.* Acute phase response in exercise. III. Neutrophil and IL-1β accumulation in skeletal muscle. *Am J Physiol* 1993;**265**:166–72.
18 **Duarte JA**, Carvalho F, Bastos ML, *et al.* Do invading leucocytes contribute to the decrease in glutathione concentrations indicating oxidative stress in exercised muscle, or are they important for its recovery? *Eur J Appl Physiol* 1994;**68**:48–53.
19 **Ohkuwa T**, Saito M, Miyamura M. Plasma LDH and CK activities after 400m sprinting by well-trained sprint runners. *Eur J Appl Physiol* 1984;**52**:296–9.
20 **Schwane JA**, Johnson SR, Vandenakker CB, *et al.* Delayedonset muscular soreness and plasma CPK and LDH activities after downhill running. *Med Sci Sports Exerc* 1983;**15**:51–6.
21 **Smith LL**, Fulme MG, Holbert D, *et al.* The impact of a repeated bout of eccentric exercise on muscular strength, muscle soreness and creatine kinase. *Br J Sports Med* 1994;**28**:267–71.
22 **Flynn MG**, Pizza FX, Boone JB Jr, *et al.* Indices of training stress during competitive running and swimming seasons. *Int J Sports Med* 1994;**15**:21–6.
23 **Koutedakis Y**, Raafat A, Sharp NC, *et al.* Serum enzyme activities in individuals with different levels of physical fitness. *J Sports Med Phys Fitness* 1993;**33**:252–7.

24 **Sawyer DW**, Donowitz GR, Mandell GL. Polymorphonucler neutrophils: an effective antimicrobial force. *Rev Infect Dis* 1989;**11**:1532–44.
25 **Benestad HB**, Laerum OD. The neutrophilic granulocyte. *Curr Topics Pathol* 1989;**79**:7–36.
26 **Hed J**. The extinction of fluorescence by crystal violet and its use to differentiate between attached and ingested micro-organisms in phagocytosis. *FEMS Lett* 1977;**1**:357–61.
27 **Sahlin S**, Hed J, Rundquist I. Differentiation between attached and ingested immune complexes by a fluorescence quenching cytofluorometric assay. *J Immunol Methods* 1983;**60**:115–24.
28 **Nosaka K**, Newton M. Difference in the magnitude of muscle damage between maximal and submaximal eccentric loading. *J Strength Cond Res* 2002;**16**:202–8.
29 **Pyne DB**. Regulation of neutrophil function during exercise. *Sports Med* 1994;**17**:245–58.
30 **Smith JA**, Telford RD, Mason JB, *et al*. Exercise, training and neutrophil microbicidal activity. *Int J Sports Med* 1990;**11**:179–87.
31 **Oetega E**. Physiology and Biochemistry: Influence of exercise on phagocytosis. *Int J Sports Med* 1994;**15**:S172–8.
32 **Muns G**. Effect of long-distance running on polymorphonuclear neutrophil phagocytic function of the upper airways. *Int J Sports Med* 1994;**15**:96–9.
33 **Gabriel H**, Muller HJ, Kettler K, *et al.* Increased phagocytic capacity of the blood, but decreased phagocytic activity per individual circulating neutrophil after an ultradistance run. *Eur J Appl Physiol* 1995;**71**:281–4.
34 **Suzuki K**, Naganuma S, Totsuka M, *et al.* Effects of exhaustive endurance exercise and its one-week daily repetition on neutrophil count and functional status in untrained men. *Int J Sports Med* 1996;**17**:205–12.
35 **Benoni G**, Bellavite P, Adami A, *et al.* Changes in several neutrophil functions in basketball players before, during and after the sports season. *Int J Sports Med* 1995;**16**:34–7.
36 **Chodzko-Zajko WJ**. The World Health Organization issues guidelines for promoting physical activity among older persons. *J Aging Phys Act* 1997;**5**:1–8.

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Traumatic humeral articular cartilage shear (THACS) lesion in a professional rugby player: a case report

I-H Jeon, W A Wallace

A 20 year old male professional rugby player was seen at the clinic for evaluation of shoulder pain after rugby play. Magnetic resonance imaging showed extensive subchondral bone bruising of the humeral head with defect of the articular cartilage. Arthroscopy showed that the inferior half of the humeral head had extensive articular cartilage loss with nearly 70% of the inferior head having lost its cartilage. Sports medicine doctors should be aware that the shoulder joint in young competitive athletes playing contact sports may be exposed to greater risk of this kind of injury.

(*Br J Sports Med* 2004;**38**:e12) http://bjsm.bmjjournals.com/cgi/content/full/38/4/e12

Avulsion fracture of peroneus longus at the first metatarsal insertion: a case report

T Murakami, K Okamura, S Harada, *et al*

Reports of isolated avulsion fracture at the planter lateral base of the first metatarsal without injury of the tarsometatarsal joint are very rare. A 24 year old man sustained an avulsion fracture at the plantar lateral base of the first metatarsal. Normal alignment of metatarsal bones and tarsometatarsal joint was maintained. In this paper, we describe internal fixation of the displaced fragment using *x* ray and minimally invasive surgery with good results.

(*Br J Sports Med* 2004;**38**:e13) http://bjsm.bmjjournals.com/cgi/content/full/38/4/e13

Little league shoulder syndrome in an adolescent cricket player

W R Drescher, A Falliner, T Zantop, *et al*

The first case of little league shoulder syndrome in a cricket player is reported. The condition has been reported in baseball pitchers and is characterised by a proximal humeral epiphyseolysis.

(*Br J Sports Med* 2004;**38**:e14) http://bjsm.bmjjournals.com/cgi/content/full/38/4/e14