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ORIGINAL ARTICLE

Are Off-Field Activities an Underestimated Risk for Hamstring Injuries in Dutch Male Amateur Soccer Players? An Exploratory Analysis of a Prospective Cohort Study

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Abstract

Purpose The purpose of this study was to explore what extent male amateur soccer players participate in off-field activities and whether these off-field activities are associated with the development of hamstring injuries.

Methods Amateur soccer players ($n=399$) from first-class selection teams ($n=32$) filled out a baseline screening questionnaire concerning off-field activities (i.e., work and study type and hours, traveling time, sleep, energy costs, and time spent on other activities) and their history of hamstring injury as a part of a cluster-randomized controlled trial. Throughout one competition, the players reported weekly their hamstring injuries, which were verified by medical/technical staff. Multivariable Firth corrected logistic regression models were used to explore associations between off-field activities and hamstring injuries.

Results Sixty-five hamstring injuries were recorded. Previous injury was significantly associated with hamstring injuries (OR ranging from 1.94 [95% CI 1.45–2.61] to 2.02 [95% CI 1.49–2.73]), but off-field activities were not.

Conclusion Although amateur soccer players spent a relatively large amount of time on off-field activities, we did not find off-field activities measured at baseline to be associated with hamstring injuries in the subsequent competitive soccer season. In contrast, previous hamstring injury was found to be strongly associated with (recurrent) hamstring injuries.

Keywords Risk factors · Activities of daily living · Psychosocial factors · Football · Athletic injuries

Introduction

Hamstring injuries are the number one muscle injury in male adult soccer and account for 15.9% of all injuries in male amateur soccer [7]. These injuries are associated with a mean rehabilitation duration of at least 28 days and up to one third of soccer players who returned to play have another muscle injury [17, 63]. Consequently, hamstring injuries are a major concern to both players and coaches and require effective prevention strategies [8, 17, 28].

Identifying causal factors associated with injuries is a prerequisite for the development of effective prevention strategies [45, 47]. Over the years, different theoretical models have been developed in which the injury mechanism is mainly viewed from a biophysiological or a biomechanical perspective [44, 47]. Another proposed conceptual framework assumes that load and recovery—both on and off the field—should be in balance for optimal performance and the prevention of injuries [39, 46]. Beside training for and playing in soccer matches, amateur soccer players also participate in numerous other activities—they work or study, and participate in social and other recreational sports and training activities.

Yet these activities are often neglected as potential causal factors that could contribute to hamstring injuries, perhaps because little is known about how much time players spend

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on these activities and what it costs them in terms of energy. These activities could lead to more physical and psychological stress and impinge on the mental and physical fitness of players [55, 58, 61]. It is known that an increase in stress could lead to stress responses (i.e., increased muscle tension) [1], which in turn may affect their susceptibility to injuries [10, 12, 16]. For this reason, it is important that coaches and staff know how much time and energy their players spend on off-field activities, and whether these activities affect a player's injury risk, and specifically risk of hamstring injuries. Therefore, assessing the off-field activities could be a part of a periodic health assessment of amateur soccer players—for example, at the start of the competition and during the winter break [4]. In addition, in case of an injury, the information on total load could be used by the coach and/or medical staff to determine load management strategies during rehabilitation.

Age and previous hamstring injury have been identified as the most important factors linked to the occurrence of hamstring injuries in male amateur soccer players [6, 21]. Little is known about the role of off-field activities in hamstring injuries, but such knowledge could contribute to the development of adequate prevention strategies [36]. In the Netherlands, Dutch males spend most of their time in paid employment, training and education, sleep, social contacts, and leisure-time activities, such as hobbies and recreational sports [52]. In addition to these activities, we would expect amateur soccer players to devote time and energy to soccer-related activities. Therefore, the aims of this study were to explore how much time amateur soccer players spend on off-field activities and whether these activities increase the risk of hamstring injuries. Although off-field activities may fluctuate throughout a competition—and could also influence different types of injuries—we explored the relation between off-field activities measured at baseline and the occurrence of hamstring injuries in the subsequent soccer season [32, 33]. In this way, we aim to establish whether off-field activities are causally associated with injuries in amateur soccer players. We hypothesized that relatively more time and energy spent on off-field activities and relatively less time spent on recovery are associated with hamstring injuries.

Methods

Study Design and Participants

This is an exploratory analysis of data from the Hamstring Injury Prevention Study–Bounding Exercise Program trial (HIPS–BEP), which has been described previously [32, 33]. The HIPS–BEP cluster randomized trial assessed the effectiveness of a hamstring injury prevention program and monitored 400 amateur players over the course of one competitive soccer season. At baseline, before the start of the intervention, all players filled out a screening questionnaire that included questions about off-field activities. This study is an exploratory analysis of the baseline screening questionnaire included in the HIPS–BEP trial. Since the data collection procedure focused on collecting data about the effectiveness of the BEP, the off-field activities were registered once at baseline, while the training exposure and hamstring injuries were registered every week. In addition, only information on hamstring injuries and their etiology were registered by the players, staff, and the researchers. This resulted in a valid data set for hamstring injury occurrence but not for other injuries. All players provided written informed consent prior to the start of the study. The trial was approved by the Medical Ethics Committee of University Medical Centre of Utrecht (16–332\C) and is registered in the Dutch trial register (http://www.trialregister.nl/trialreg/index.asp) (NTR6129). The report of this study follows the STROBE guidelines [18].

Eligibility Criteria

Male amateur soccer players were considered eligible for participation if they were 18–45 years and played in the first team of a soccer club in the Dutch first-class amateur competition series. Potential candidates were excluded if they did not give informed consent, failed to complete any questions related to off-field activities in the baseline questionnaire, only joined the included soccer teams after the start of the study, or had insufficient Dutch language skills to validly fill out the questionnaires.

Baseline Measurements

Before the start of the 2016/2017 competition, all enrolled participants completed a questionnaire on player characteristics, such as age, height, weight, number of years' experience as soccer player, standard field position, leg dominance, and number of hamstring injuries in the previous competitive season. The questionnaire also included questions about off-field activities, such as work and study duration, traveling time, sleep, total time spent on other activities, participation in sports other than soccer, and the total energy cost of these activities combined. These off-field activities were chosen, because they cover a large part of daily life in the general Dutch population—and, therefore, in the daily life of amateur soccer players as well [52]. Work and study duration were quantified by the number of hours spent on work and study in a 'normal' week. The intensity of work and study was categorized by one researcher (JB) as low, intermediate, or high physical activity, according to previously proposed, accelerometer based, categories [59]. In case of uncertainty, two researchers (PAvdH, MB) were consulted to provide consensus. The players indicated the number of hours per week they spent on traveling and the average number of hours they slept per night. In addition, players scored the energy cost of all activities beside soccer on a scale ranging from 0 (no energy at all) to 10 (all of my energy). Finally, the players were asked the total time (in hours) they spent on their social activities and hobbies other than soccer. Like pre-season strength or psychological tests [13, 15], the baseline questionnaire was administered with a view to providing coaches with knowledge of factors that could increase the risk of hamstring injury in their players.

Outcomes

Each week, all players received an email or short message service (SMS) in which they were asked four questions regarding the number of minutes spent training, the number of minutes spent playing in a match, hamstring injury occurrence, and general injury occurrence. In the case of a hamstring injury, both player and medical staff were contacted by phone or email to verify the hamstring injury, after which they separately received a standardized hamstring injury questionnaire to record the incidence, severity, and etiology of the injury [23]. To classify the injury as an acute or an overuse injury, both the player and the medical staff had to indicate whether the injury occurred acutely or after a prolonged period of overload.

Players were classified as injured (score 1) if they had sustained at least one mild (time loss of 4–7 days) or more severe hamstring injury [23]. All other players were classified as uninjured (score 0). Recurrent hamstring injuries were defined as an injury of the same type and at the same site as the index injury that occurred after a player had returned to play [35].

Data Analysis

Statistical analysis was performed in R with the brglm package (version 0.6.1) and logistf (version 1.22) package [29, 41, 50]. We selected confounders using clinical reasoning and analyzed the data accordingly. The variables that were considered for inclusion in the analysis were: group allocation (whether the player was in the intervention or control group in the original study; included as a confounder), previous injury, work and study duration, work and study intensity, traveling time, sleep, total time spent on other activities, and total energy cost of these activities. Prior to multivariable analysis, the data were screened and checked for data-entry errors, outliers and missing data. Missing data were assumed to be Missing At Random (MAR) as defined by Rubin [53] and were imputed by multiple imputation with chained equations [24], with the variables: age, weight, length, work/study duration, work /study intensity, traveling time, and sleep.

Since hamstring injuries were relatively rare, we analyzed the data using multivariable logistic regression analysis with Firth correction to penalize log likelihood and adjust for small sample bias [57]. To assess a possible causal association between off-field activities and hamstring injury, different multivariable models were tested. In the first analysis, all off-field activities were included. In the final analysis, five models were tested: four models on load (defined as number of hours and intensity of an activity), namely, work, study, traveling time, and other activities, and one on recovery (sleep). We included interaction terms between duration and intensity in the work and study models. Incidence of previous injuries was analyzed as a continuous variable to minimize loss of information.

Results

Participant Characteristics

Of 588 adult male amateur players from 32 soccer teams assessed for eligibility [32], 400 filled out the baseline questionnaire, one of whom did not answer any questions related to off-field activities. The data of the remaining 399 players were included in the final analysis. An overview of baseline data is presented in Table 1.

In total, 39 players did not complete some of the questions about off-field activities—there was missing information (expressed as a percentage) on category of work (0.07%), work hours (0.5%), study category (0.5%), study hours (2.5%), traveling time (1.8%), sleep (1.5%), energy costs (3.8%), and total time spent on other activities (4.0%). There were no missing data on previous and new hamstring injuries. Overall compliance with the weekly questions on hamstring injury occurrence was 71%.

Outcome Data

At baseline, the players indicated that they spent on average 38.1 h per week on work and study, 7.42 h on traveling, slept

Table 1 Characteristics of male amateur soccer players ($n = 399$)

Characteristics	Mean (SD)
Age (years)	24.81 (4.35)
Weight (kg)	78.77 (7.89)
Height (cm)	183.99 (6.36)
Experience (years)	18.68 (4.62)
Training exposure (min per week)	143.78 (80.08)
Match exposure (min per week)	56.53 (45.64)

an average of 7.36 h per night, and spent a total of 10.55 h on other activities (Table 2). At the start of the study, all activities had a mean energy cost of 6.98 on a scale of 1–10. Participants played other sports beside soccer: 125 players played one other sport, 15 players played two other sports, and one player played three other sports. The most popular other sports were fitness ($n = 78$), futsal ($n = 16$), and running ($n = 13$). There had been 149 hamstring injuries in the previous competition which resulted in a mean of 0.37 hamstring injuries per player in the previous competitive season.

In the 2016/2017 competition, 57 players reported 65 hamstring injuries through weekly email or SMS services, 8 of which were recurrent injuries. The hamstring injuries were validated with a follow-up questionnaire filled out by the player and medical staff separately; five of the questionnaires were not filled out completely. Of the 65 injuries, 40 occurred on the non-dominant leg, and 21 occurred on the dominant leg; the side of the injury was not known in 4 cases. There were 36 acute and 23 overuse injuries, and 6 of unknown origin. Injuries occurred mostly in relation to matches (2 injuries before, 29 injuries during, 11 injuries after a match), with 15 injuries occurring during training and 8 injuries of which the moment of occurrence was unknown. Of the players with validated injuries, 53 players had at least one injury with a severity of mild or higher and these players were included in the analysis for off-field activities. The mean duration of rehabilitation for the hamstring injury was 23.57 days (range 4–104).

Main Results

The first multivariable logistic regression model used non-imputed data and included the baseline data on average weekly work hours and intensity, weekly study hours and intensity, weekly traveling time, sleep duration (average hours per night), amount of time spent on other activities (per week), total energy cost of these activities (on a scale from 1 to 10), and previous hamstring injury. In this model, only previous hamstring injury was significantly associated with hamstring injury incidence (adjusted odds ratio [OR] 1.90 [95% CI 1.42–2.62], $P < 0.05$). None of the off-field activities measured at baseline were significantly associated with hamstring injury occurrence.

In the second analysis, the multivariable logistic regression analysis was repeated using imputed data. Again, previous hamstring injury was the only variable significantly associated with hamstring injury (OR 1.95 [95% CI 1.44–2.66]). In the final analysis, imputed data were used for five models (work, study, traveling time, sleep, and time spent on other activities) (Tables 3, 4, 5, 6, 7). In all models, previous hamstring injury was again the only factor significantly associated with a new hamstring injury.

Table 2 Off-field activities and injury history of male amateur soccer players ($n = 399$)

Variables	Mean (SD)
Work duration (hours per week)	27.13 (17.72)
Study duration (hours per week)	10.53 (14.68)
Total duration of work and study (hours per week)	38.10 (10.62)
Traveling time (hours per week)	7.42 (6.78)
Sleep (hours per night)	7.36 (1.17)
Energy costs (on a scale of 0 to 10)	6.98 (1.80)
Time spent on other activities (hours per week)	10.55 (9.34)
Hamstring injuries in current season (number per player)	0.37 (0.82)

Table 3 Multivariable logistic regression analysis of the effect of work on hamstring injury occurrence in male amateur soccer players ($n = 399$)

Variables	OR	95% CI[a]
Intercept	0.09	0.02–0.35
Group allocation (BEP/CON[b])	0.92	0.50–1.69
Previous injury (average)	1.94	1.45–2.61[c]
Work duration (hours per week)	1.00	0.90–1.10
Work intensity		
-Low	2.08	0.35–12.25
-Intermediate	0.40	0.06–2.78
-High	0.31	0.02–3.78
Work duration × work intensity low	1.06	0.89–1.26
Work duration × work intensity intermediate	0.98	0.88–1.10
Work duration × work intensity high	1.02	0.91–1.15
Energy costs (scale 1–10)	1.03	0.92–1.16

[a]Confidence interval; [b]bounding exercise program/control group; [c]$P < 0.001$

Table 4 Multivariable logistic regression analysis of the effect of study on hamstring injury occurrence in male amateur soccer players ($n = 399$)

Variables	OR	95% CI[a]
Intercept	0.07	0.02–0.29
Group allocation (BEP/CON[b])	0.89	0.48–1.66
Previous injury (average)	2.02	1.49–2.73[c]
Study duration (hours per week)	1.01	0.94–1.08
Study intensity		
-Low	0.66	0.20–2.22
-Intermediate	15.67	0.87–283.70
Study duration × study intensity low	1.06	0.88–1.28
Study duration × study intensity intermediate	1.01	0.93–1.10
Energy costs (scale 1–10)	0.80	0.62–1.05

[a]Confidence interval; [b]bounding exercise program/control group; [c]$P < 0.001$

Table 5 Multivariable logistic regression analysis of the effect of traveling time on hamstring injury occurrence in male amateur soccer players ($n=399$)

Variables	OR	95% CI[a]
Intercept	0.08	0.02–0.32
Group allocation (BEP/CON[b])	0.91	0.50–1.66
Previous injury (average)	1.97	1.47–2.65[c]
Travelling time (hours per week)	0.99	0.94–1.04
Energy costs (scale 1–10)	1.06	0.89–1.26

[a]Confidence interval; [b]bounding exercise program/control group; [c]$P<0.001$

Table 6 Multivariable logistic regression analysis of the effect of sleep on hamstring injury occurrence in male amateur soccer players ($n=399$)

Variables	OR	95% CI[a]
Intercept	0.08	0.01–0.68
Group allocation (BEP/CON[b])	0.92	0.50–1.70
Previous injury (average)	1.99	1.48–2.67[c]
Sleep (hours per week)	1.00	0.79–1.27
Energy costs (scale 1–10)	1.05	0.88–1.26

[a]Confidence interval; [b]bounding exercise program/control group; [c]$P<0.001$

Table 7 Multivariable logistic regression analysis of the effect of other activities on hamstring injury occurrence in male amateur soccer players ($n=399$)

Variables	OR	95% CI[a]
Intercept	0.08	0.02–0.30
Group allocation (BEP/CON[b])	0.91	0.49–1.67
Previous injury (average)	1.99	1.48–2.69[c]
Other activities (hours per week)	0.99	0.95–1.03
Energy costs (scale 1–10)	1.07	0.89–1.28

[a]Confidence interval; [b]bounding exercise program/control group; [c]$P<0.001$

Discussion

In this study, we explored how much time and energy male amateur soccer players devoted to off-field activities and whether these off-field activities (measured at baseline) were associated with the occurrence of hamstring injuries in the subsequent soccer season. Although players spent a larger part of their time on off-field activities, these activities were not significantly associated with the incidence of hamstring injuries in that competitive soccer season. In contrast, a previous hamstring injury was significantly associated with hamstring injury in multivariable analyses (OR ranging from 1.94 [1.45–2.61] to 2.02 [1.49–2.73]), consistent with earlier results [3, 19]. We found that the re-injury rate was high (12.3%), that most injuries were acute and strain injuries rather than overuse or other types of injuries, and that most injuries occurred during matches rather than during training. These injury characteristics are in line with those reported in other studies [3, 19, 25–27, 65].

As expected, the players spent the majority of their time (about 56 h/week at baseline) doing off-field activities, such as work, study, traveling time, other obligations and hobbies, and/or other sports. Of all the included soccer players, 125 soccer players (31.3%) played at least one other sport beside soccer. While the time spent on work was comparable to that of men of the same age in the general Dutch population, the time spent on study, work and study combined, and in particular sport was higher among the study participants than in the general Dutch adult population (total training and match exposure in this study ≈ 200 min vs. 102 min, respectively) [52]. We expected that the physical intensity of work—classified according to the summary scores of accelerometry data proposed in the study of Steeves et al. [59]—would be an important factor affecting the risk of hamstring injury. In previous studies that included general adult populations from various occupations, the physical demands of work, such as lifting or kneeling down, were associated with acute and overuse injuries, such as meniscal tears, sprains or strains, and osteoarthritis [51, 55, 58, 60]. This could possibly apply to the hamstrings as well. However, one could also argue that these activities improve an individual's physical fitness, motor or functional abilities, and result in a protective adaptation [54], although there is no evidence for this. We did not measure how the intensity and time/energy the players invested in their work or study, but instead categorized the type of work or study and its intensity following recent recommendations [59]. However, these categories are based on accelerometer data, and therefore, only provide a global estimate of intensity. They do not take into account local mechanical loads placed on the lower extremities and could, therefore, lack specificity. This lack of specificity might also be true for the psychosocial aspects of work and study. We recorded hours spent on these activities but did not objectify the mental stress associated with these activities.

Other physical activities, such as physically demanding hobbies or other sports, could also contribute to the higher than average physical loads placed on the players. In this study, players spent 10.55 h on other activities and 125 players participated in at least one other sport, but there was no evidence of an association between time spent on other activities—measured at baseline—and hamstring injury occurrence. This lack of association could be explained by the "health paradox of occupational and leisure-time physical activity" [34]. This paradox states that occupational physical activity decreases physical fitness, whereas leisure-time physical activity costs energy, but also increases physical fitness [34]. In this study, we asked the players how much time they spent on other activities, such as hobbies, but we did not specify these activities. In addition, while we asked the players which sports beside soccer they played, we did not ask them how much time they spent on these sports. Therefore, it remains unknown whether these other activities should be classified as occupational activities (household chores) or leisure-time activities (other sports).

Finally, the players spent on average more than 7 h per week traveling, without the mode of transport being specified. It is important to appreciate that in the Netherlands cycling is a popular form of transport. Cycling contributes to a better physical fitness and could even increase hamstring muscle strength, which could protect against injuries [20, 56]. It would be interesting to compare the injury rate in players who use an active form of transportation (cycling) and in players who use a passive form of transport (car).

To compensate for the demands of off-field activities, players could use sleep as a recovery strategy. The amateur players in our study slept 7 h and 22 min, which is less than Dutch professional players (8 h and 11 min) and the general Dutch population (8 h and 6 min) [40, 64]. We hypothesized that sleeping for a shorter time hinders recovery and increases the risk of injury, as has been seen in other athletes [42, 48]. However, there was no association between sleep duration and hamstring injury occurrence in this study. This might be because we used self-reported sleep duration, which, while it might reflect objective sleep duration, does not take the quality of sleep into account [43]. Sleep quality influences the training load-recovery balance and may be more important than sleep duration in terms of injury occurrence [2, 22].

The total amount of time spent on off-field activities in addition to the time spent on soccer training, and the lower sleep duration compared with that of the general Dutch population suggests that the physical load-recovery balance is disturbed in these amateur soccer players [52]. As this balance is determined by an individual's capacity to withstand physical and mental activity and stress, a possible explanation for the lack of association between off-field activities and hamstring injuries is that we did not take individual differences into account. Individuals differ in how they respond to physical activity, and an intensity of physical activity that is acceptable to one player may cause injury in another [11, 39, 62]. Because the players already collected data on a weekly basis, which could be considered a hassle, we did not want to burden them further by asking them for information about their psychosocial well-being and physical capacity, and thus only have information on the load of the players' off-field activities at baseline. We did, however, ask the players the perceived total energy cost of their off-field activities combined. While the average cost was relatively high (6.98 out of 10) compared with the daily perceived exertion of office workers and cleaners [5], the total energy cost was not significantly associated with hamstring injuries.

This study is one of the largest prospective cohort studies of hamstring injuries in amateur soccer players to date, including 399 amateur players from clubs across the whole country and 65 hamstring injuries verified by both player and medical/technical staff. This makes it possible to translate the results to other male amateur first-class teams in similar competitions. Another major strength of this study is that it opens the discussion on whether off-field activities should be considered in association with hamstring injuries in male amateur soccer players. However, despite using multiple imputation, Firth correction, and different models, the analysis remains exploratory, and therefore, the findings need to be verified in larger samples.

One of the limitations of this study, and with screening at baseline in general, is that all potential factors associated with hamstring injury were assessed once. While this is often done for factors, such as strength or psychological predictors in the preseason [13, 15], this form of screening excludes variations during the competition. For example, it is known that daily hassles do change from week to week in elite junior, high school, and senior soccer players, and that these changes are associated with a higher injury incidence [37, 38]. Therefore, screening of off-field activities before the start of the competition (baseline) does not identify players at increased risk of sustaining a hamstring injury during the following competition. It, therefore, remains an interesting question if frequent registration of, or fluctuations in, off-field activities contribute to a better understanding of the causal pathway of hamstring injuries. To account for the daily fluctuations in off-field activities and their energy cost, a longitudinal design with repeated measures would be more appropriate. For future research, it would be interesting to measure off-field activities repeatedly and combine them with, for example daily hassles, so that a dynamic system approach can be used to provide insight into a player's resilience [14, 30, 49]. Although the cohort was large and the injury rate was comparable to that of other large cohort studies [19, 36], the number of injuries was relatively low in the present study. To reduce sparse data bias as a result of the low number of injuries, we used the Firth correction on the multivariable logistic regression analysis. The Firth correction removes a portion of small sample bias by penalizing the likelihood, which, in combination with profile likelihood based confidence intervals, improves the accuracy of logit coefficients in small samples. [57].

It could be informative to measure the contribution of—or the fluctuations in—all off-field activities to the total load of a player with sensor technology in daily life. This information could be combined with self-reported measures for work and/or study, traveling time, sleep intensity and duration, [31] and with external and internal load of on-field activities. A complex dynamic systems approach could then be used to establish whether these activities are associated with hamstring injuries [9, 49].

Conclusion

In this prospective study, we measured the amount of time amateur soccer players spent on off-field activities. The results show that Dutch amateur soccer players spend on average 38.1 h/week working or studying, 7.42 h/week traveling, 7.36 h/day sleeping, and 10.55 h/week on other activities. The perceived energy cost of these activities was 6.98 out of 10. We found no evidence of an association between off-field activities and the development of hamstring injuries, but can confirm that a previous hamstring injury is strongly associated with the development of a new hamstring injury in male amateur soccer players.

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Availability of Data, Materials and Code The full script and the data sets used for the analysis are available upon request.

Declarations

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethics Approval The trial was approved by the Medical Ethics committee of University Medical Centre of Utrecht (16–332\C) and is registered in the Dutch trial register (http://www.trialregister.nl/trialreg/index.asp) (NTR6129).

Consent to Participate Informed consent was obtained from all individual participants included in the study.

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