Strength and Conditioning Habits of Competitive Distance Runners

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ABSTRACT

Targeted strength and conditioning (S&C) programmes can potentially improve performance and reduce injury risk factors in competitive runners. However, S&C practices of distance runners are unknown. This study aimed to explore S&C practices of competitive middle- and long-distance runners and examined whether reported frequency of injuries were influenced by training behaviours. 1883 distance runners (≥ 15 years old) completed an online survey. All runners who raced competitively were included in data analysis (*n*=667). Distance runners mainly engaged with S&C activities to lower risk of injury (63.1%), and improve performance (53.8%). The most common activities utilized were stretching (86.2%) and core stability exercises (70.2%). Resistance training (RT) and plyometric training (PT) were used by 62.5% and 35.1% of runners respectively. Junior (under-20) runners include PT, running drills and circuit training more so than masters runners. Significantly more international standard runner's engaged in RT, PT and fundamental movement skills training compared to competitive club runners. Middle-distance (800 m-3000 m) specialists were more likely to include RT, PT, running drills, circuit training and barefoot exercises in their programme than longer-distance runners. Injury frequency was associated with typical weekly running volume and run frequency. S&C did not appear to confer a protection against the number of injuries runners experienced. Practitioners working with distance runners should critically evaluate the current S&C practices of their athletes, to ensure that activities prescribed have a sound evidence-based rationale.

Key words: athletes, training practices, endurance, running, survey

INTRODUCTION

Endurance runners typically utilize long slow distance, threshold tempo, and interval running to train the physiological variables that underpin their performance (32). Although it is well-established that these methods of training will provide an improvement in performance (23), there is also evidence that bi-weekly explosive and heavy resistance training (RT) sessions can enhance time-trial performance (3-10 km) and several important physiological parameters (4). In particular, running economy (RE), defined as the oxygen or energy cost of running at a given sub-maximal speed, has shown improvement following 6-8 weeks of resistance training for a range of ages and training levels (10). For well-trained distance runners, RE tends to predict performance more accurately than $\dot{V}O_{2max}$, (9) and requires lengthy periods of endurance training to generate improvements (23). Strength training (RT and plyometric training (PT)) therefore potentially offers a time efficient strategy to improve RE in this sub-population.

RT and other forms of strength and conditioning (S&C) should also form part of a well-rounded approach to the long-term development of adolescent athletes (5), and is recommended for young distance runners (24). Equally, older athletes benefit from resistance training (35), and improvements in RE have been observed following a period of strength training in masters marathon runners (29). Despite these findings, it is uncertain what proportion of runners currently engage with strength training, and whether runners of a specific age and competitive status are more likely to participate.

It is estimated that up to 70% of competitive runners sustain an injury, which prevents them training for at least one week, each year (17). Risk factors for injury in runners, such as reduced flexibility (43), muscular weakness and asymmetry (14,25,27), and neuromuscular control (13) can potentially be addressed with a targeted programme of S&C. It is currently unknown whether endurance runners participate in training activities to enhance these qualities in the belief that injury risk could be reduced. Other injury prevention and recovery strategies such as core stability exercises, stretching, and foam rolling are also popular with athletes (8,21,26,42), however the degree to which these modalities are used by distance runners is currently unknown.

A number of studies have documented the training practices of distance runners (1,15,19,20,39), however only two papers mention the runners engagement with S&C-related activities (19,39). In a cohort of 50 non-elite marathon runners, it was reported that 24% included weight lifting as part of their marathon preparation, increasing to 40% in the month after the event (39). Similarly, in a group of 93 marathon runners, just over half included strength training in their programs (19). It is unclear whether the same trends in participation exist for runners who compete over shorter distances.

There are currently no studies that have specifically investigated the S&C practices of distance runners. Such information could be used to understand the impact of the current scientific knowledge and influence the development of professional coaching courses and programmes of education for the coaches of athletes. Therefore, the primary aim of this study was to identify the extent to which distance runners engage with S&C and the characteristics of those who participate in various activities. The study also aimed to examine whether reported injury rates relate to the training behaviours of runners.

METHODS

Experimental Approach to the Problem

A four-part, 16-question survey was administered to a convenience sample of distance runners (800 m – marathon) to anonymously identify their typical running behaviour and S&C practices. The survey was designed in collaboration with two S&C coaches, a running coach, an exercise physiologist, and an academic who specializes in survey design. Following targeted pilot testing with ten runners of varying age and competitive level, there was further refinement of questions. The readability of the survey was assessed prior to use and deemed appropriate for individuals aged over 12 years (Flesch reading ability score: 71.2). The survey was available on-line via the Bristol Online Survey platform for a period of 12 months (April 2016 to March 2017).

Subjects

Prior to launch of the survey, institution level ethical approval was granted. Approval was also obtained from the *parkrun* research project board to advertise the survey via their newsletter. The survey was open to any distance runners age 15 years old and above. The title page of the survey included information on the purpose of the study and a statement of consent, which subjects were required to agree to in order to progress to the questions. A parent/guardian of participants under the age of 18 provided a statement of consent, which was sent via email to the lead investigator. Subjects were also recruited via running pages on social networking websites and emails sent to coaches, clubs and runners worldwide through the contacts acquired by the lead investigator.

Procedures

The survey was split into four sections and contained fixed-response questions, which generated categorical and ordinal data. Section one of the survey identified participant demographics and section two contained a series of questions concerning their typical running habits. The third section of the survey required participants to detail their typical S&C practices. Items relating to how participants learned about the most appropriate techniques was also included (section four).

Statistical Analyses

Data were analysed using the IBM Statistical Package for Social Sciences (version 22) software. Descriptive statistics are displayed as mean ± standard deviation and significance was accepted at $p<0.05$. Training behaviour questions were cross-tabulated with subject characteristics and injury frequency using Chi-squared (χ^2) tests of independence. Fishers exact statistic was used if the expected response count was < 5. Where significance was detected, follow-up *post-hoc* tests were performed using a Bonferroni Correction via the adjusted standardized residuals. Multinomial logistic regression was used to model the predictive capacity of training behaviours on injury frequency and calculate adjusted odds ratios (OR) with associated 95% confidence intervals (CI). Binary logistic regression (forward method) was applied for questions relating to participation in S&C activities, as responses were dichotomous.

RESULTS

Characteristics of Respondents

A total of 1883 surveys were completed. To filter those respondents who were not competitive distance runners, and therefore potentially perform S&C for other sports or recreational reasons, participants who answered '*I only participate and don't compete'* to a competitive level question were excluded from analysis. The competitive level and age-distribution of the remaining 667 runners (male *n*=383; female *n*=284) are presented in Table 1 and Figure 1 respectively. The majority (67.3%) of runners surveyed competed at longer distance events (5000 m-half marathon), however under-20 and under-17 runners were mainly middle-distance (800 m-3000 m) specialists (76.5%). More than 75% of the respondents typically ran ≤ 64 km per week (Figure 2). However, there was a significant difference between competitive level and average reported running volume (χ^2 (20)=188.8, p<0.001), with local club runners tending to run ≤ 64 km per week (p<0.001), national standard runners 65-96 km per week (p<0.001) and international runners > 129 km per week (p<0.001). Seventy percent of runners performed high-intensity running (interval training and tempo running) 1-2 times per week and a further 20% performed 3-4 sessions per week of this nature.

Table 1 about here

Figure 1 about here

Figure 2 about here

Figure 3 about here

Engagement with S&C

The reasons that runners included S&C activities in their training routines are presented in Figure 3. Across all ages and competitive levels, runners typically performed S&C activities to improve their performance (53.8%) and lower their risk of sustaining an injury (63.1%).

Table 2 shows the engagement with S&C activities, and for those who included each activity, the typical prescription they adopted. The most commonly used S&C activities were stretching (86.2%) and core stability exercises (70.2%). For those who included each activity, there were no differences in the frequency, duration or timing of the activities across age groups or competitive levels ($p>0.05$). A runners sex did not discriminate whether they participated in RT or PT, but more females than males included circuit training (38.0% vs 19.0%, $p<0.001$), stretching (90.1% vs 83.3%, $p=0.011$) and core stability (74.7% vs 66.8%, $p=0.029$) in their programmes.

*** Table 2 about here ***

Only 35.1% of runners utilized PT as part of their training. A disproportionately high number of under-17 ($p=0.01$) and under-20 ($p<0.001$) runners and a lower number of masters 50-59 and 60+ years ($p<0.05$) incorporated this activity ($\chi^2(6)=34.40$, $p<0.001$) as illustrated in Figure

4. A significant difference was also detected for the standard of runner who utilized PT ($\chi^2(4)=34.56$, $p<0.001$, Fig 5), with significantly fewer local club standard runners using this modality ($p<0.001$) and significantly more regional, national and international runners taking part in the activity ($p<0.001$). A logistic regression model was statistically significant, ($\chi^2(3)=38.77$, $p<0.001$), but age category, competitive distance and level and could only explain 7.8% (Nagelkerke R^2) of the variance in whether runners performed PT or not. The model correctly classified 62.5% of cases, with under-20 runners associated with a low likelihood of not participating (OR: 0.35, 95%CI: 0.15-0.83, $p=0.017$). An international runner was 3.13 times (95%CI: 1.24-7.92, $p=0.016$) more likely to include PT than a county standard runner.

Approximately 60% of runners used RT, and cross-tabulation analysis detected a significant difference for those who utilized RT and the standard of runners ($\chi^2(4)=16.43$, $p=0.002$, Fig 5). Post-hoc analysis revealed a significantly small proportion of local club runners took part in RT ($p<0.001$), but a high number of national ($p<0.05$) and international ($p<0.05$) runners participated. A logistic regression model was statistically significant, ($\chi^2(3)=16.90$, $p=0.001$), for age, race distance and competitive level as explanatory factors for whether runners participated in RT. Age group and race distance had poor predictive power ($p>0.05$) but competitive level alone classified 62.5% of cases correctly. An international runner was 3.37 times (95%CI: 1.27-8.92, $p=0.014$) more likely to take part in RT compared to a local club runner.

Fundamental movement skills were used by only 27.7% of the runners surveyed, however 47.2% of the international runners made use of this activity, which represented a higher proportion than other competitive levels (*p*<0.01). Running technique drills were used by half (50.4%) of the runners surveyed with under-17 and under-20 runners using them more than older age groups (*p*<0.001), and higher standard (regional, national and international) runners using them more than lower standard (*p*<0.002). Logistic regression showed an international runner was 3.59 times (95%CI: 1.69-7.60, *p*=0.001) more likely to perform running drills compared to a local club runner. Bodyweight exercises were used by 60.4% of runners with senior runners using them more so than other age categories (*p*=0.002). Circuit training was used by a small number of runners (27.1%) but a high proportion of junior (under-17 and under-20) runners used this technique compared to older age groups (*p*<0.001; >80% probability).

Stretching was included in the programmes of most runners (86.2%) of all age and ability. Runners typically stretched for <15 min, after running sessions at a higher frequency than other S&C activities. Core stability exercises were also widely used (70.2%) across all age categories but tended to be less used by local club runners (*p*=0.004) compared to other standards of runners. An international runner was 3.07 times (95%CI: 1.17–8.05, *p*=0.023) more likely to use core stability exercises than a local club runner. Few runners use barefoot exercises in their training routine (14.8%).

For many S&C activities (RT, PT, running drills, circuit training and barefoot exercises) engagement was significantly higher in those who competed in middle-distance (800 m-3000 m) events compared to long-distance (5000 m-half marathon) runners (*p*<0.001). For example, middle-distance specialists were 2.67 times more likely to participate in RT compared to a long-distance runner, and 6.68 times more likely than an ultra-distance runner. Similarly, middle-distance runners were 3.53 times more likely to perform PT and 4.26 times more likely to include running drills compared to those in the long-distance category.

Injury

Overall, 67.4% of runners had suffered at least one injury in the last year. Cross-tabulation revealed an positive association between number of injuries and both typical mileage ($\chi^2(25)=44.7$, $p<0.001$) and running frequency ($\chi^2(25)=41.0$, $p<0.001$). A significant difference was detected between injury rate and runners participation in RT ($\chi^2(5)=15.2$, $p=0.010$), bodyweight exercises ($\chi^2(5)=21.3$, $p=0.001$), stretching ($\chi^2(5) = 18.9$, $p=0.002$), foam rolling ($\chi^2(5)=29.8$, $p<0.001$) and core stability exercises ($\chi^2(5)=13.5$, $p=0.019$). Specifically, post-hoc analysis showed that of those who had not sustained any injuries in the last year, a small number participated in each of these activities ($p<0.001$). A multinomial logistical regression for typical mileage, running frequency and participation in these five S&C activities could explain 20.2% (Nagelkerke R^2) of the variance in response to injury rates, however no factors in their own right were able to predict any level of injury incidence.

Figure 4 about here

Figure 5 about here

DISCUSSION

This is the first study to document the S&C practices of competitive distance runners. Runners who engaged in S&C activities were mainly motivated by improving their performance and lowering their risk of injury. Stretching and core stability were the most popular activities, however almost two-thirds of runners perform regular RT, including a high proportion of junior runners. Middle-distance specialists and runners who compete at a higher level were most likely to perform S&C activities. Participation in S&C does not seem to be associated with lower injury rates but higher running training volumes appear to be related to the number of injuries runners experienced.

Stretching and core stability exercises were used by a high proportion of runners (86.2% and 70.2% respectively) despite a lack of evidence showing these strategies are effective at reducing injury risk (3,18,21,33), enhancing recovery (3) and improving performance (3,42). Foam rolling was also used by 54.7% of runners mainly after training sessions or as an independent session, which can be effective for enhancing recovery and improving range of motion (8). In a group of 112 elite adolescent athletes, 68% and 38% of respondents included stretching and foam rolling as a recovery modality respectively, which is lower than the participation reported here for both the whole cohort of competitive runners and juniors only (26).

Over half (53.8%) of those surveyed perform S&C activities with the goal of improving performance, and 76.9% of those runners include strength training (RT and/or PT) in their programmes. Although extensive research supports the benefits of strength training on several determinants of distance running performance (4,10), few studies have reported the extent to which runners engage with these activities. Of the competitive runners surveyed, 62.5% included RT in their programmes and 35.1% used PT. Depending upon the exercise selected and training-status of the runner, bodyweight exercises (60.4% participation rate) may also provide sufficient overload in non-strength trained individuals to induce neuromuscular adaptation and thus improve strength qualities.

Evidence suggests a training frequency of two strength sessions per week is required to obtain benefits (4,10), however one session per week has also shown positive outcomes if high-intensity exercises are used (6,12). The strength training performed appears to be in-line with this recommendation as most runners reported they typically perform both RT and PT 1-2 times per week as independent sessions or as part of an S&C session. This volume of work is also the same as previously reported for a group of well-trained Spanish runners (11).

S&C activities are recommended for adolescent athletes to develop a wide-range of physical competencies, improve neuromuscular co-ordination and enhance performance (22). The engagement within the under-17 and under-20 age groups across all S&C modalities was significantly higher compared to the overall participation rate for each activity, and for PT (Figure 4), running drills and circuit training, participation was significantly greater than for older age groups. There is currently a lack of literature which directly examines the impact of strength training on young distance runners specifically (24), however sprint performance (5-40 m) has been shown to be positively affected in males (31).

The competitive level of participants was linked to engagement with RT, PT (Figure 5) and fundamental movement skills, which is in agreement with findings from Karp (19) who observed that elite male runners performed more strength training than national class men.

Benefits of strength training activities have been reported for runners of all abilities (10), however the barriers to participation amongst lower standard runners are not known. Time-constraints, fatigue, a lack of knowledge and the cost associated with facility access have been cited as reasons for non-participation in physical activity (36), therefore if these same barriers exist for strength training in runners, practitioners should devote time to educating their athletes and finding innovative strategies to improve engagement.

There was a tendency for middle-distance runners to participate in S&C activities to a greater degree than runners who compete over longer-distances. Shorter events require a greater contribution from anaerobic energy sources (16), therefore middle-distance specialists are perhaps more likely to include strength training in their programmes, which has been shown to enhance speed (24,30) and anaerobic power in runners (28). Nevertheless, RE is an important factor for any middle- (7) or long-distance runner (34) and has consistently been shown to improve following a period of strength training (10). Therefore all distance runners should consider including strength training modalities in a well-rounded training regimen, regardless of event specialism.

Runners mainly chose to include S&C in their programme in the belief it lowers the risk of injury (63.1%). The mechanisms of injury are multi-faceted and complex, however several modifiable risk factors have been identified for common overuse injuries in runners, including gluteal weakness (25,27), neuromuscular control (13), asymmetry (14) and low bone mineral density (40). RT, particularly for musculature around the hips, has been shown to be effective at minimizing the risk of some types of overuse injury (41). Studies conducted on injury prevention approaches using athletes from other sports have also shown balance training and warm-ups that utilize neuromuscular control exercises to be effective at reducing certain injuries (21). Less than a third (31.6%) of runners included balance training in their programmes, and a similar number indicated they include neuromuscular control type activities (fundamental movement skills and PT) in their warm-up routine, however it is unknown whether these activities specifically are reducing injury risk in runners.

Higher weekly mileage and training frequency were associated with higher rates of injury, which is in agreement with risk factors identified by others (37). Of the runners who reported no injuries, a low proportion participated in some S&C activities (RT, bodyweight exercises, stretching, foam rolling, core stability). There was also a significant link between those who reported running the highest volume and participation in these S&C activities. When S&C participation and running volume variables were entered into a logistical regression model, they could only explain a small proportion of the variance in injury rates reported by runners (20.2%). This suggests that although a link may exist between injury rates and each factor, they are likely to be independent of one another.

A number of limitations are important to acknowledge for a study of this nature. Survey response data provides meaningful information on the association between specific characteristics of respondents and participation in S&C activities, however this does not imply causality. Therefore the data can only be used to determine patterns in participation and whether this aligns to recommendations from scientific literature. Similarly, the study cannot ascertain the reasons a runner does not participate in S&C activities, which would be useful information to aid coaches with increasing engagement. Although a relatively large sample size was obtained for this study, this doesn't completely eliminate the potential for bias created by convenience sampling. It is also possible that despite our best efforts to maximize the readability of the survey, some questions may have been misinterpreted, thus producing inaccurate data. Similarly, there is also the potential that some recall bias may exist within the responses to retrospective self-reporting questions. Finally, non-competitive participants were excluded from data analysis to reduce the likelihood that they performed S&C activities for other sports or reasons, however we cannot completely eliminate this possibility.

PRACTICAL APPLICATIONS

The most commonly utilized S&C training activities were stretching and core stability despite limited evidence that use of these modalities enhance performance or reduce injury risk. This underscores the need for practitioners working with distance runners to critically appraise the training activities they prescribe, and endeavour to educate their athletes on the methods which are most likely to reap the greatest benefits, such as RT and PT. Although the relatively high participation in some S&C activities is an encouraging finding, there were still many participants who lack engagement, therefore there is a need for governing bodies and running organizations to improve their programmes of education and outreach efforts. The results of this study should also be used by coaches to illustrate the extent to which elite runners engage with various S&C modalities, as this is likely to have contributed towards their success. Younger (under-20) runners, international competitors and middle-distance specialists were most likely to engage in strength training activities, however coaches need to be aware that distance runners of all ages, abilities and specialisms can also benefit from these activities. Future research should investigate the barriers to participation in S&C for sub-groups (club-standard and masters runners) to assist coaches and organizations with developing initiatives to improve engagement.

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Figure 1. Age distribution of competitive runners (*n*=667).

Figure 2. Typical weekly running volume of competitive runners (*n*=667).

Figure 3. Reasons that runners include S&C activities as part of their training (multi-response question).

Figure 4. Percentage of respondents in each age category who participate in resistance training (RT) and plyometric training (PT). [a] significantly higher participation than the Chi-squared expected frequency ($p \leq 0.01$), [b] significantly lower participation than the Chi-squared expected frequency ($p<0.05$).

Figure 5. Percentage of respondents in each competitive category who participate in resistance training (RT) and plyometric training (PT). [a] significantly lower participation than the Chi-squared expected frequency ($p<0.001$), [b] significantly higher participation than the Chi-squared expected frequency ($p<0.001$), [c] significantly higher participation than the Chi-squared expected frequency ($p<0.05$).

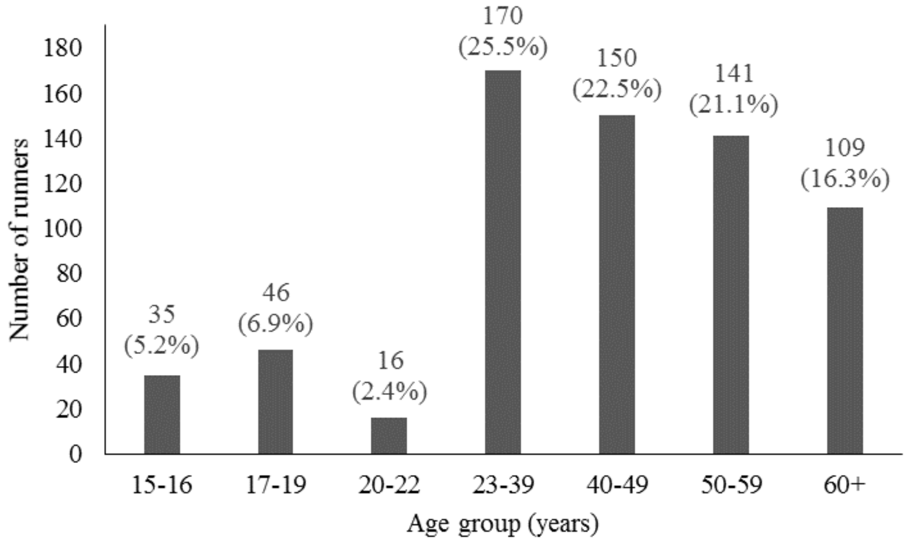
	Local club	**County**	**Regional**	**National**	**International**
Male	271 (70.8%)	28 (7.3%)	33 (8.6%)	30 (7.8%)	21 (5.5%)
Female	200 (70.4%)	27 (9.5%)	14 (4.9%)	28 (9.9%)	15 (5.3%)
Total	471 (70.6%)	55 (8.2%)	47 (7.0%)	58 (8.7%)	36 (5.4%)

Table 1. Competitive level of male and female respondents (*n*=667).

Activity	Number who participate	Frequency (per week)	Duration of activity per session	Positioning of activity in training routine
Stretching	575 (86.2%)	1-4 (66.2%)	<15 min (64.5%)	After running (56.9%)
Core stability	468 (70.2%)	1-2 (68.9%)	<30 min (80.8%)	Independent session (45.9%) or part of S&C session (41.2%)
Resistance training	417 (62.5%)	1-2 (81.0%)	<30 min (56.6%)	Independent session (44.3%) or part of S&C session (42.3%)
Bodyweight exercises	403 (60.4%)	1-2 (70.6%)	<30 min (75%)	Independent session (46.5%) or part of S&C session (36.8%)
Foam rolling	365 (54.7%)	1-2 (74.5%)	<15 min (74.5%)	Independent session (46.6%) or after running (43%)
Running drills	336 (50.4%)	1-2 (77.4%)	<15 min (61.3%)	Warm-up (68%)
Plyometric training	234 (35.1%)	1-2 (89.3%)	<15 min (66.7%)	Part of S&C session (35.8%) or warm-up (34.9%)
Balance training	211 (31.6%)	1-2 (81.6%)	<15 min (70.1%)	Part of S&C session (45.6%) or independent session (39.4%)
Fundamental movement skills	185 (27.7%)	1-2 (69.1%)	<15 min (55.6%)	Warm-up (40.2%) or part of S&C session (32.2%)
Circuit training	181 (27.1%)	1-2 (87.4%)	15-45 min (58.9%)	Independent session (58.6%)
Barefoot exercises	99 (14.8%)	1-2 (76.1%)	<15 min (73%)	Independent session (34.4%) or part of S&C session (34.4%)

Table 2. Frequency of respondents who use S&C activities and the typical prescription of each activity. Percentages identified are based upon only those who use each activity.

Figure 1.



180
160
140
120
100
80
60
40
20
0
Number of runners
35 (5.2%)
46 (6.9%)
16 (2.4%)
170 (25.5%)
150 (22.5%)
141 (21.1%)
109 (16.3%)
15-16
17-19
20-22
23-39
40-49
50-59
60+
Age group (years)

Figure 2.

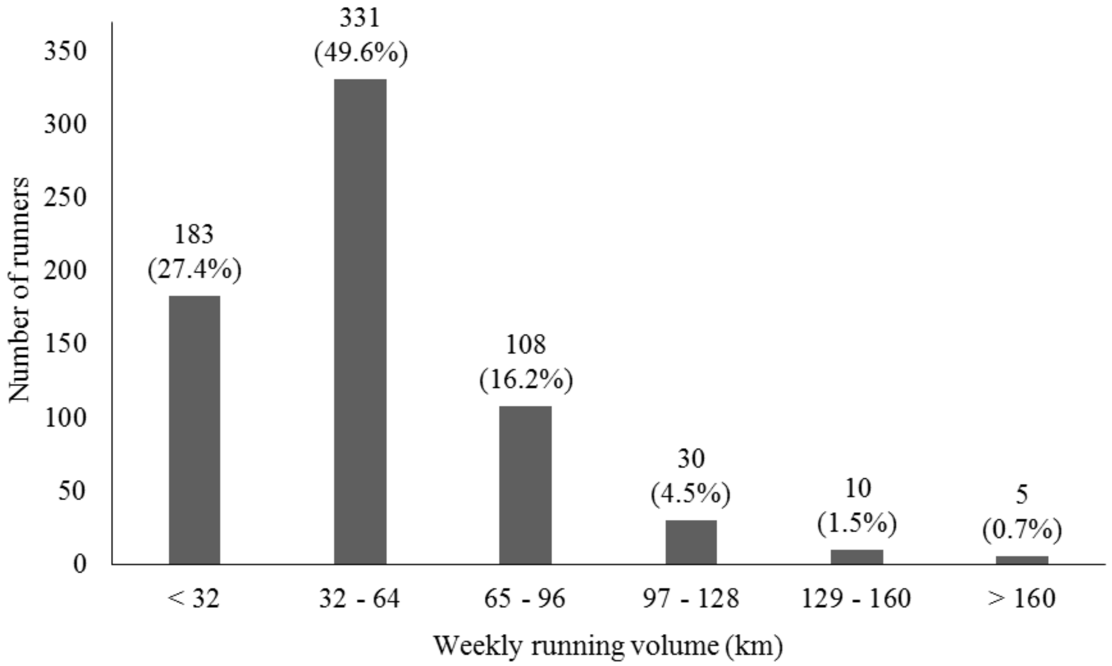

331
(49.6%)
183
(27.4%)
108
(16.2%)
30
(4.5%)
10
(1.5%)
5
(0.7%)
350
300
250
200
150
100
50
0
Number of runners
< 32
32 - 64
65 - 96
97 - 128
129 - 160
> 160
Weekly running volume (km)

Figure 3

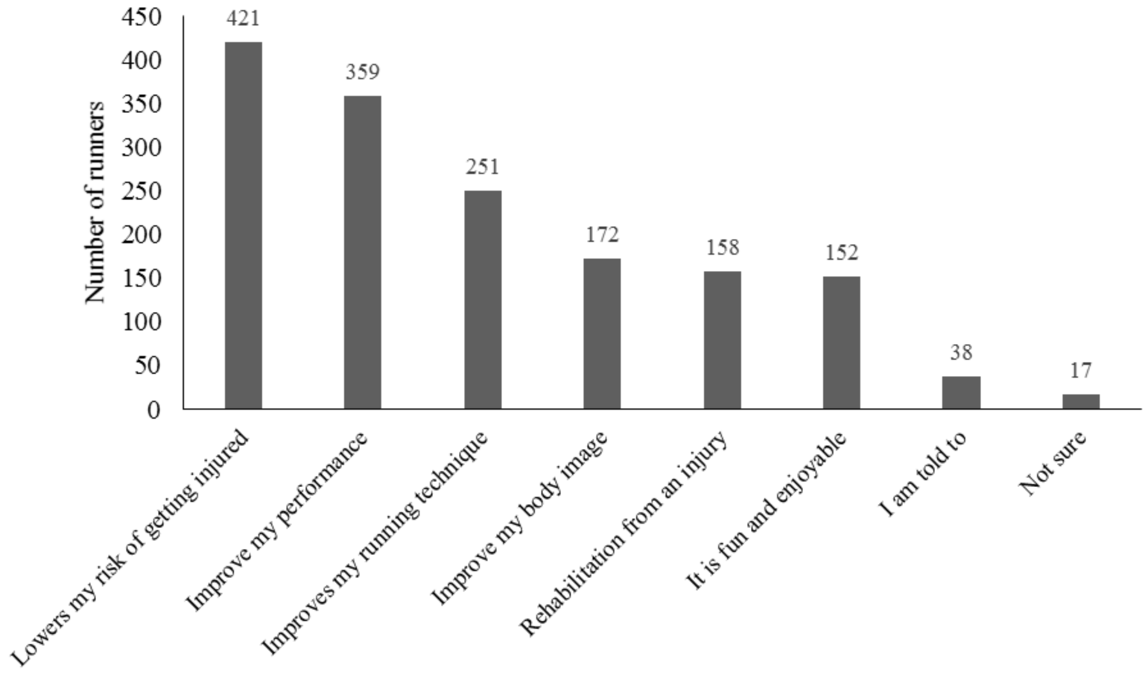
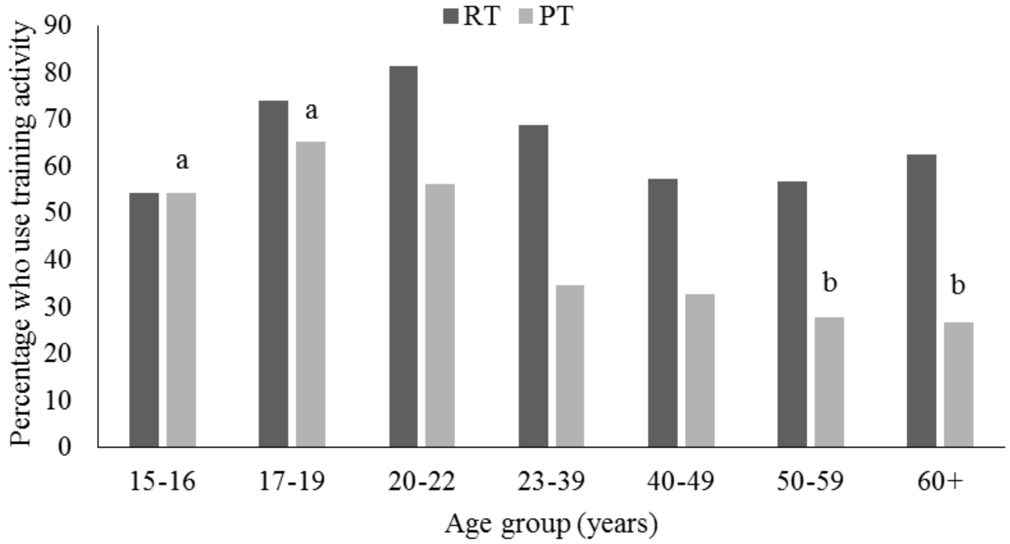
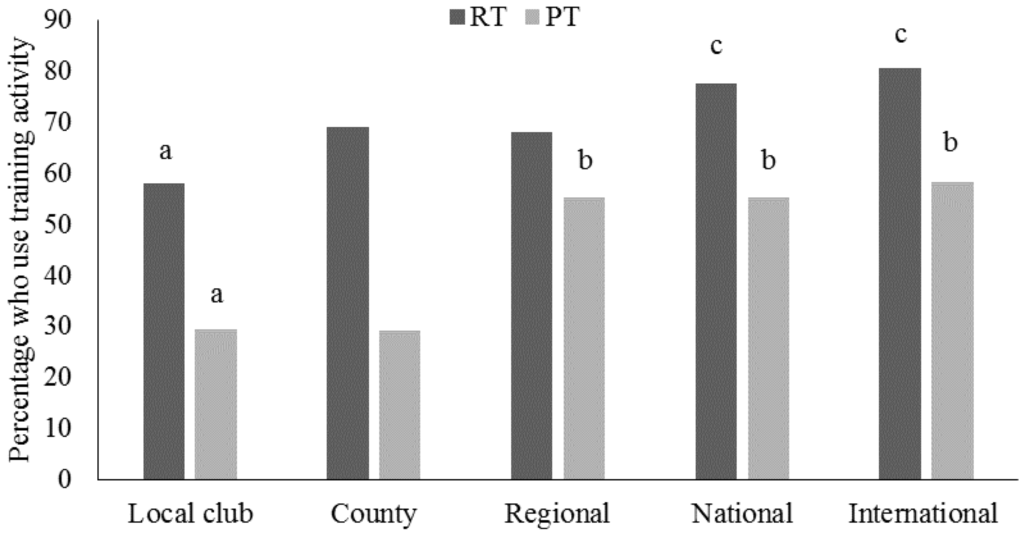

Number of runners
450
400
350
300
250
200
150
100
50
0
421
359
251
172
158
152
38
17
Lowers my risk of getting injured
Improve my performance
Improves my running technique
Improve my body image
Rehabilitation from an injury
It is fun and enjoyable
I am told to
Not sure

Figure 4



RT
PT
Percentage who use training activity
0
10
20
30
40
50
60
70
80
90
a
a
b
b
15-16
17-19
20-22
23-39
40-49
50-59
60+
Age group (years)

Figure 5


RT
PT
Percentage who use training activity
0
10
20
30
40
50
60
70
80
90
a
a
b
c
b
c
b
Local club
County
Regional
National
International