WORLD-CLASS LONG-DISTANCE RUNNING PERFORMANCES ARE BEST PREDICTED BY VOLUME OF EASY RUNS AND DELIBERATE PRACTICE OF SHORT INTERVAL AND TEMPO RUNS

Running head: Deliberate practice in distance running

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ABSTRACT

The aim of this novel study was to analyze the effect of deliberate practice (DP) and easy runs completed by elite-standard and world-class long-distance runners on competitive performances during the first 7 years of their sport careers. Eighty-five male runners reported their best times in different running events and the amounts of different DP activities (tempo runs and short and long interval sessions) and 1 non-DP activity (easy continuous runs) after 3, 5 and 7 years of systematic training. Pearson's correlations were calculated between performances (calculated using the IAAF scoring tables) and the distances run for the different activities (and overall total). Simple and Multiple Linear Regression Analysis calculated how well these activities predicted performance. Pearson's correlations showed consistently large effects on performance of total distance ($r \geq 0.75$, $P < 0.001$), easy runs ($r \geq 0.68$, $P < 0.001$), tempo runs ($r \geq 0.50$, $P < 0.001$) and short interval training ($r \geq 0.53$, $P < 0.001$). Long interval training was not strongly correlated ($r \geq 0.22$). Total distance accounted for significant variance in performance ($R^2 \geq 0.57$, $P < 0.001$). Of the training modes, Hierarchical Regression Analysis showed that easy runs and tempo runs were the activities that accounted for significant variance in performance ($P < 0.01$). Although DP activities, particularly tempo runs and short interval training, are important for improving performance, coaches should note that the non-DP activity of easy running was crucial in better performances, partly because of its contribution to total distance run.

Key words: elite-standard athletes, endurance training, long-distance events, track and field.

INTRODUCTION

In global competitions such as the Olympic Games and International Association of Athletics Federations (IAAF) World Championships, the long-distance running races typically include the 5,000 m, 10,000 m and marathon events, with the IAAF also holding separate cross country and half marathon world championships. Success in these events depends predominantly on physiological determinants such as maximal oxygen uptake (VO_{2max}), running speed at VO_{2max} (vVO_{2max}), running economy (RE) and lactate threshold (LA) (33), as well as anaerobic capacity and sprinting ability (16). High-intensity training sessions that are intended to improve these determinants in long-distance runners include short intervals (between 200 m and 1000 m long and from 95 to 100% of maximum heart rate (HR_{max}) in intensity), long intervals (between 1000 m and 2000 m long and from 92 to 95% of HR_{max}), tempo running (between 45 and 70 min in duration or running intervals from 1000 m to 5000 m and from 82 to 92% of HR_{max}) and official competitions or time trials at race pace (from 5000 m to marathon-distance long and from 82% to 95% of HR_{max}) (4,16). Because these modes of training are physically and mentally taxing, athletes usually supplement their training with easier running sessions, conducted typically over distances between 8 km and 40.5 km and from 62 to 82% of HR_{max} (16). These easy running sessions can function as base training during the early season, as active recovery sessions in between harder sessions, or as a continuous stimulus for cardiovascular conditioning and development of connective tissue adaptations (16,32). Whereas competitive club runners might alternate hard and easy sessions daily, world-class athletes typically train more than once a day, with their easy sessions taking place in the mornings (32). Because of their less taxing nature, easy runs can be carried out over longer distances and therefore important in accumulating greater overall running distances. For the strength and conditioning professional, an understanding of how important these easy runs are

relative to more race-specific training sessions will assist in developing programs that get the most out of the time spent training.

A key principle of improving performance is that there should be specificity in training (29). In terms of skills development, deliberate practice (DP) is a theory of practice that is conducted with the specific goal of improving performance, and in sports requires considerable effort, concentration and enjoyment, and should be considered by athletes as very relevant in improving their performance (14,15,40). Once DP has been identified according to the accomplishment of these characteristics, it can be quantified throughout a sports career through the use of training logs and personal interviews (41). The original research on DP focused on musicians (15), but its proposed potential for improvement has encouraged research across many domains to determine what aspects of practice can be taught to expert aspirants (13,19). Sport is one of these domains where there has been considerable research in the last 25 years (12,23,24,26,38), including the disciplines of middle and long-distance running (9,10,40,41). A recent study on elite-standard long-distance runners (9) found that world-leading Kenyan runners reported very high physical and mental effort and enjoyment in very intense training activities (i.e., short and long interval workouts, tempo runs and races), similar to research on DP in elite-standard Canadian middle-distance runners (40). By contrast, subjects in both the Kenyan and Canadian cohorts did not consider easy runs to require physical or mental effort and thus did not fulfil the original definition of DP. How much of a contribution to performance is made by specific DP activities has yet to be reported for elite-standard long-distance runners, but a new study on these types of training session will inform coaches and athletes of their relative merits with regard to the overall training volume.

Although DP has been proposed as an essential component of improvement (simple experience in the task alone is not sufficient (38)), recent scientific research has argued that differences in performance variability were just partially explained by adopting DP activities (20,30,31). Therefore, current trends in DP theory claim that practice is not the only variable that explains different standards of performance (31). This is clearly the case in excellent long-distance runners, whose abilities and performances are affected by physiology, genetics, biomechanics, nutrition, altitude, training methods and psychology (39). In this review (39), the authors did not refer to the effect of training using DP, but given its importance in other sports, is likely to have relevance to their success. DP studies are typically retrospective, having been used with musicians (15), triathletes and swimmers (25) and middle-distance runners (41), with several studies reporting high reliability for long-term recall of physical and sports activities (5,17,22,23). Baker et al. (2) demonstrated the reliability of the "training journal method" for supporting recall for athletes in individual sports, and training logs and schedules are very frequently used by coaches and athletes to monitor progress and make comparisons with previous running seasons (32). To date, the importance of DP as a predictor of performance in long-distance runners has yet to be explored, but the vast personal training data that elite-standard athletes record will allow for in-depth analysis of training volumes and the sessions completed. The aim of this novel study was to analyze the amount and type of DP, as well as the easy runs, completed by elite-standard and world-class long-distance runners during the first 7 years of their sport careers, with reference to their best performances in competition.

METHODS

Experimental Approach to the Problem

A Taxonomy of Training Activities Questionnaire (TTAQ) was provided to 85 male long-distance runners to measure how much each subject took part in different types of training

sessions during their sports career (1, 3, 5 and 7 years after beginning systematic training). Modes of training (e.g., easy runs, tempo runs) were analyzed using Pearson's correlations and linear regressions, with competition performances (converted into points using the IAAF's scoring system) used as the dependent variable.

Subjects

Eighty-five male elite- and international-standard long-distance runners took part. The age range was between 18 and 43 years old, with a mean age of 28 (± 5). All subjects were specialists in the 5000 m, 10000 m, half marathon (21.195 km) or marathon (42.195 km) events. At the time of data collection, all athletes were competing in at least one of these events. The Institutional Review Board approved the details of the study, which was conducted in accordance with the declaration of Helsinki, including consent documentation and information to subjects before commencement. In accordance with the Institutional Review Board's policies for use of human subjects in research, all subjects were informed of the benefits and possible risks associated with participation before taking part and informed of their right to withdraw at any point. All subjects were over the age of 18 and gave written informed consent to indicate their voluntary participation. The subjects' performances ranged from world-class to competitive national standard. Amongst the best athletes, there were medalists from the IAAF World Cross Country Championships, IAAF World Championships (marathon), Olympic Games, Commonwealth Games, African Championships, European Cross Country Championships and European Championships (track). These runners' best times ranged from 2:03:23 (a former World Record holder) to 2:36:15 in the marathon, and from 58:54 to 1:08:48 in the half marathon; the current World Record holder for the 10 km road race (26:44) was also included in the sample. The subjects' best times gave scores ranging from 494 to 1285 points

in the IAAF scoring tables (35). Only the time periods in which subjects reported both training data and performance data (competition results) were analyzed in this study.

Procedures

To explore how much each subject took part in practice or systematic training during his sports career, a Taxonomy of Training Activities Questionnaire (TTAQ) was developed based on Young & Salmela's (40,41) questionnaire developed for middle distance runners. This instrument was based on Ericsson et al.'s (15) original study on musicians, adapted for long-distance running and validated by 3 experienced long-distance running coaches.

Each subject received a 3-part questionnaire. The first part asked subjects to provide biographical information, current age, athletics event and personal records. In the second part, subjects were required to recall information for each 2-year interval from the time they began systematic practice (i.e., at 1, 3, 5 and 7 years) until the time of data collection. At each time interval, subjects were asked to report how much time they had engaged in different training activities (not running), and how much distance they had run in different running activities during a typical week of training 10 weeks before their season goal race (e.g., Olympic Games, World Championships, European Championships, national championships) (41). The relevant training activities included were cross training, flexibility training, weight training, work with the coach, easy runs, tempo runs, long interval training, short interval training and competition and time trials (9,41). For each of the latter 5 activities, subjects were further instructed to account for total weekly distance (km). The latter 4 activities (i.e., not including easy runs) were the activities that subjects considered more important and, for this study, were considered DP. This consideration was taken as the same subjects of this study rated these activities with high values (mean superior to 7 in a 10-points Likert type scale) and significantly higher than

5 on the scale for relevance, physical and mental effort and enjoyment ($P < 0.001$, Cohen's d ≥ 1.86) in 2 previous studies (9,10). Easy runs were considered mentally effortless as its rating was not significantly higher than 5 on the Likert scale for concentration ($P = 0.06$, $d = 0.27$) (9,10).

Subsequently, subjects were asked to report their best finishing times in competitions after 1, 3, 5 and 7 years of systematic training. As 70% of subjects did not report competition times for the first year of systematic training, details reported for this stage were not included.

In the third part of the questionnaire, subjects were required to provide information on long periods of no training or full rest weeks during their sports career. In this way, it was possible to assess the number of training weeks per year. As carried out by Young & Salmela (41), for the beginning year of systematic training, typical hours of involvement per week were multiplied by the number of weeks per year to derive the annual total. This was then multiplied by 2 to calculate the 2-year interval total, and these totals were then summed for accumulated amounts of practice at 3 years (i.e., including the "beginning year" value, plus the interpolated value for the next 2 years), 5 years and 7 years (15,26). Because establishing the validity of data collected using retrospective recall can be problematic, recruiting high- and elite-standard runners as this study's sample worked well because most possessed detailed training logs covering years or even decades of training. 72% of the subjects indicated that they used a training log to help them to complete the questionnaire. Some athletes did not keep hold of the training information; rather, their coaches had recorded these data.

Statistical Analyses

Statistical analyses of data were performed using the Statistical Package for the Social Sciences

24.0 (SPSS, Chicago, IL, USA). Data were screened for normality of distribution and homogeneity of variances using a Shapiro-Wilk normality test and a Levene test, respectively. Simple Linear Regressions and associated equations were calculated to analyze the relationships between running performance scores after 3, 5 and 7 years of systematic training (dependent variable) and total distance accumulated after 3, 5 and 7 years of systematic training (independent variables). Linear regression assumptions were checked using residual versus fitted, normal QQ, and Cook's distance plots. Pearson's correlations were calculated between running performance after 3, 5 and 7 years of systematic training and total distance accumulated and different types of running activities after 3, 5 and 7 years of systematic training, respectively, and starting age of systematic training. Correlation effects were interpreted as small (r value of $0.10 - 0.29$), moderate ($0.30 - 0.49$), large ($0.50 - 0.69$) or very large (≥ 0.70) (27).

A hierarchical linear regression analysis was conducted between subjects' performance scores after 3, 5 and 7 years of systematic training (dependent variable) and running activities and starting age of systematic training (independent variables). Pearson's correlations were used to set the order of the variables introduced in the regression analysis. Only variables that were correlated significantly to performance were introduced into the hierarchical regression analysis. Nine athletes were excluded from the 5-year analysis, and 21 from the 7-year analysis, because at the time of data collection they had not yet trained systematically for that period of time. Pearson's multivariate coefficient of determination (R^2), unstandardized beta (regression) coefficient (B), standard error of B (B SE), standardized beta (regression) coefficient (β), and F for change in R^2 were calculated. Significance for all analyses was set at $P < 0.05$.

RESULTS

Table 1 shows the means and standard deviations of total distance accumulated, and total distance of DP activities and easy runs. The mean starting age for systematic training was 18 years old (± 5). Simple linear regression analysis between performance scores and total distance accumulated was significant after 3 years of systematic training ($P < 0.001$, $R^2 = 0.583$); predicted performance (IAAF score) is equal to 406.5 + 0.03 km. The same analysis for 5 years of systematic training also showed significance ($P < 0.001$, $R^2 = 0.592$); predicted performance (IAAF score) is equal to 502.2 + 0.2 km. Performance scores and total distance accumulated was also significant after 7 years of systematic training ($P < 0.001$, $R^2 = 0.566$); predicted performance (IAAF score) is equal to 593.0 + 0.01 km.

*** Table 1 about here ***

*** Figure 2 about here ***

Pearson's correlations between running performance scores after 3, 5 and 7 years of systematic training and total volume and different types of running activities after 3, 5 and 7 years of systematic training and starting age are shown in Table 2. The total volume of training showed the strongest correlation with performance scores, explaining up to 59% of the total variability between athletes (Figure 1). Easy runs were more correlated with performance scores than DP activities (tempo runs, long interval training and short interval training). The total volume of distance run was also strongly related to performance after 3, 5 and 7 years of systematic training ($r = 0.75 – 0.77$) (Table 2). Accumulated easy runs ($r = 0.68 – 0.72$), tempo runs ($r = 0.50 – 0.58$) and short interval training volumes ($r = 0.53 – 0.56$) had stronger relationships with running performance scores after either 3, 5 or 7 years of systematic training than long

interval training (r = 0.22 – 0.31), which was not significant after 7 years of training. Competitions and time trials were not significantly correlated to performance at any stage. The correlation score between starting age and performance was only large after 7 years (r = 0.52).

*** Table 2 about here ***

Hierarchical regression analysis was conducted between subjects' performances and easy runs, tempo runs, short interval training, long interval training and starting age of systematic training after 3, 5 and 7 years of systematic training (Table 3). R^2 increased through the different models in all stages although the only variables that can be considered predictors of performance were easy runs and tempo runs in all stages and models. The β value for easy runs decreased through all stages, although it always remained significant ($P < 0.01$).

*** Table 3 about here ***

DISCUSSION

The aim of this study was to analyze the amount and type of DP, as well as the easy runs, completed by elite-standard and world-class long-distance runners during the first 7 years of their sport careers, with reference to their performances as scored using the IAAF tables. The first finding was that the total volume of distance run in training was a strong predictor of performance scores; indeed, just the total volume of training itself explained up to 59% of performance score variability between athletes (Figure 1). This is not hugely surprising given the long-distance events the athletes take part in, where training for an event such as the marathon requires regular running sessions that come close to its race distance (42.195 km). Even for those athletes covering shorter distances, the regular racing and high-intensity training

that is undertaken requires a well-developed aerobic base (16). The starting age of systematic training showed a moderate effect on performance scores, similar to earlier research (31,41). However, starting age did not account for significant variance in performance (Table 3) but, as most if not all athletes would have completed some sort of running before beginning systematic training, in that running is a universal practice (unlike skills used in musicianship, for example) adopted from an early age, many athletes would have developed some aerobic conditioning during their formative years. Indeed, it is highly likely that those who decided to begin systematic training already had an aptitude or liking for it, and so their systematic training was effectively refining many of the skills already developed.

The main training contributor to the total distance run during the athlete's careers was the easy runs, accounting for approximately two-thirds of each 2-year accumulated total. Previous studies on training intensity distribution in elite-standard endurance sports similarly stated that most training is performed at low intensities (28,36). As the Hierarchical Regression Analysis showed that easy runs were the training activity that most accounted for variance in performance scores in all stages (Table 3), they are the single training activities that best predict the performance scores of subjects. However, these cannot be considered a DP activity because they don't require high physical effort and concentration (9,10,41), and means that even though DP is considered very relevant by subjects to improve performance (9), the most fundamental practice required to succeed in long-distance running is not DP. This might be because, although DP plays an important role in performance and talent development, it cannot explain by itself variability of performance in absolute terms because other factors also contribute to explain performance differences (31). This is not to understate the importance of DP in a holistic training regimen, which needs to have variety (16,29). Nevertheless, original DP theory claims that these forms of domain-relevant kinds of practice are less important than DP as

predictors of expertise (7,15) because experience in itself is not enough to reach world-class performances (38). This assertion has been widely disputed by studies that demonstrated the relevance of, for example, playful activities on developing expertise (1,8,34), and what this novel study on a range of running abilities shows is that there is a crucial role for long, easy runs that contribute to greater volumes of running, allow for improving the efficiency of metabolic key components for energy fueling (36) and facilitate enjoyment and camaraderie between teammates (32).

DP activities are built upon the easier, "base-forming" runs and allow athletes to develop other important aspects of physiological functioning, such as running economy and maximal running speed (16). One key finding of this study was that some forms of DP training (tempo running and short interval training) had large correlations with performance scores after 3, 5 and 7 years of systematic training (Table 2). Tempo runs were the most important predictor within the DP activities, agreeing with Tjelta (37) on the relevance of this kind of training, particularly with regard to improving LA (4). Over the course of their careers, the relevance of tempo runs seemed to increase, highlighting the importance of progressive specialization from the most fundamental training sessions (easy runs) to those most specific to long-distance racing (tempo runs) (Table 2). These results were highlighted by the Hierarchical Regression Analysis (β for tempo runs increased from 0.258 after 3 years of systematic training to 0.293 after 7 years in the 4th model, whereas β for easy runs decreased from 0.532 after 3 years to 0.366 after 7 years in the 4th model) (Table 3). These results agree with classical talent development studies (6,11), and show the importance of progressive overload and specificity of training for athletic improvement (29). For each 2-year period analyzed, tempo runs accounted for about 20% of total distance run, demonstrating again the importance of covering great distances in training. To a great extent, tempo running replicates what happens in long-distance racing, as it is at a

high intensity (unlike easy runs) and does not have rest periods (that interval training typically does). Coaches should note the importance of this type of training on performance and plan for increased intensity of tempo runs as part of an athlete's progression.

Like tempo running, short interval training showed a large association with performance; previous research on world-class Kenyan athletes highlighted its use in their training regimens (4). Hence, although short interval training didn't account for significant variance in performance (Table 3), any small effects it has on overall performance could be critical in differentiating between very closely matched athletes (e.g., during the end spurt). This is not to take away from the importance of greater running volume or tempo runs, but indicates that short interval training can be built upon these foundations. By contrast, long interval training showed the lowest effect on variability of performance (of the training modes), as well as the smallest correlations. The DP activities of long and short interval training accounted for 7 – 8% of total distance accumulated, but athletes might want to consider emphasizing short interval training given the results shown in this study. In terms of the highest intensity activities, competitions are of course the truest reflection of a runner's ability, but taking part in them did not lead in turn to improvement. In a sense, this might be because world-class athletes tend to focus on winning, rather than achieving fast times, in championship racing (21), and because peaking for competitions usually occurs at the end of the season, with any small gains lost before the start of the following season. The large variation in distance covered in races reflects the wide range of distances covered in competition (5,000 m to marathon), and which necessitate different tapering and recovery periods. Nonetheless, competitions throughout the season are an excellent method of monitoring progress in training and learning racing and pacing strategies. Although the use of logs and diaries for retrospective analysis of training loads and modes can present difficulties with recall (and hence this study was limited

to those world-class and high-standard athletes who had reliable data), the study's novel findings with regard to training advice are made based on long-term training regimens, actual results in competition (rather than laboratory-based, for example) and from a sizeable cohort of successful athletes.

Furthermore, one limitation in particular has to be acknowledged. DP theory aims to quantify the amounts of practice at different activities using the same methodology regardless of the field that is being studied. It means that the same methodology is used for violinists and endurance athletes. In this sense, the intensity of training accounted for by DP theory is based on athletes' general perceptions using a Likert scale at each training activity (15). However, each field has its own characteristics and, even more importantly, has displayed specific and accurate methodologies of quantifying amounts of practice. In the case of middle- and long-distance endurance events, different validated methodologies have been developed. Accordingly, a training load objective quantification method based on a heart rate index was evolved (3), developing the concept of Training Impulse (Bannister's TRIMPS). Subsequently, a subjective method of training load quantification (session-RPE) based on the perceived exertion shown by athletes at each training session (intensity) and the duration of the training session was also proposed and validated (18). Therefore, the accuracy and reliability displayed by session-RPE and Bannister's TRIMPS when determining activities like easy runs, tempo runs and short and long interval training are considerably higher than the quantification method used by DP theory, mainly because intensity is not accounted for during training, but retrospectively and, in general, perceived effort is rated when all the training sessions have been conducted. Nonetheless, this methodology has been shown to be accurate, valid and reliable in a huge variety of domains (12,14), and it represents the only way of assessing the training conducted by this sample of athletes with such high standards of performance.

PRACTICAL APPLICATIONS

The first important finding that coaches should note was that the strongest relationships found for performance scores were with total distance run after 3, 5 and 7 years of systematic practice. There is thus a fundamental need for athletes to run over considerable distances (> 100 km per week) to compete with world-class athletes, and even with those who are below this highest standard. It is not possible to always train at high intensities, particularly over these long distance, so the large associations found between easy runs and performance scores are welcome in terms of managing training intensity in long-distance running regimens, notwithstanding their central role in developing cardiovascular fitness. Tempo runs contribute to performance by being both an important source of accumulated distance run and in terms of their role in physiological improvements and specificity to racing; similarly, short interval training appeared to be a key component of a varied training schedule, although long intervals were less important. Further DP studies should analyze not only the difference in accumulated DP (by distance) in different performance groups but more so the influence of DP on performance because it very likely differs across domains. Taking into account this novel study's findings, there are nonetheless numerous other factors that play an important role in performance and that strength and conditioning professionals have to take into account, such as biomechanics, tactical acumen and psychological responses to stress.

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Table 1. Total accumulated distance run as deliberate practice runs and easy runs (mean ± SD).*

Variables	After 3 years of systematic training (N = 85)	After 5 years of systematic training (N = 77)	After 7 years of systematic training (N = 65)
Performance (IAAF scores)	787 ± 250	882 ± 233	945 ± 207
Total distance (km)	12933 ± 6503	23069 ± 10676	33446 ± 14822
Easy runs (km)	8264 ± 4191	14797 ± 7022	21981 ± 9879
Tempo runs (km)	2647 ± 2718	4525 ± 4242	5848 ± 5637
Long interval training (km)	903 ± 759	1731 ± 1116	2816 ± 1529
Short interval training (km)	981 ± 783	1741 ± 1277	2327 ± 1555
Competition and time trials (km)	224 ± 428	398 ± 716	602 ± 1062

*IAAF = International Association of Athletics Federations.

Table 2. Pearson's correlation values between running performance (measured as IAAF score) and training starting age, total volume of training, easy runs, tempo runs, long interval training and short interval training volumes (km) after 3, 5 and 7 years of systematic training.

	After 3 years N = 85 r	After 5 years N = 77 r	After 7 years N = 65 r
Total volume	0.76§	0.77§	0.75§
Easy runs	0.72§	0.71§	0.68§
Tempo runs	0.50§	0.54§	0.58§
Long interval training	0.27*	0.31†	0.22
Short interval training	0.55§	0.53§	0.56§
Competitions and time trials	−0.06	−0.07	0.03
Starting age	0.29†	0.45§	0.52§

IAAF = International Association of Athletics Federations. * $P < 0.05$, $^\dagger P < 0.01$, $^\S P < 0.001$.

Table 3. Summary of Hierarchical Regression Analysis for variables predicting performance (IAAF score) after 3 years (N = 85), 5 years (N = 78) and 7 years of systematic training (N = 65).*

	Model 1			Model 2			Model 3			Model 4		
After 3 years	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Easy run	.037	.005	.611§	.031	.006	.524§	.030	.006	.496§	.032	.006	.532§
Tempo run	.023	.007	.253†	.022	.007	.240†	.021	.007	.233†	.024	.008	.258†
Short interval				.049	.029	.154	.052	.029	.164	.048	.029	.150
Long interval							.035	.024	.106	.034	.024	.104
Starting age										−4.23	4.06	−0.09
R^2		.565			.580			.591			.597	
F for change in R^2		53.36			37.35			28.90			23.36	
After 5 years	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Easy run	.019	.003	.588§	.019	.003	.561§	.017	.003	.511§	.016	.004	.492§
Tempo run	.016	.005	.292†	.016	.005	.282†	.016	.005	.282†	.015	.005	.266†
Short interval				.009	.019	.049	.012	.018	.066	.013	.019	.070
Long interval							.030	.016	.143	.029	.016	.140
Starting age										2.67	5.32	.048
R^2		.576			.577			.596			.597	
F for change in R^2		50.21			33.20			26.55			21.07	
After 7 years	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Easy run	.011	.002	.521§	.010	.002	.459§	.009	.002	.420†	.008	.003	.366†
Tempo run	.013	.003	.354§	.012	.004	.322†	.012	.004	.340†	.011	.004	.293†
Short interval				.016	.015	.124	.017	.015	.129	.019	.015	.143
Long interval							.013	.011	.100	.011	.011	.088
Starting age										6.87	5.12	.137
R^2		.560			.568			.577			.590	
F for change in R^2		39.39			26.77			20.48			16.96	

*IAAF = International Association of Athletics Federations. R^2 = Pearson's multivariate coefficient of determination; B = unstandardized beta (regression) coefficient; SE B = standard error of B; β = standardized beta (regression) coefficient; F for change in R^2 = ANOVA F for change in the Pearson's multivariate coefficient of determination. † P < 0.01, § P < 0.001.
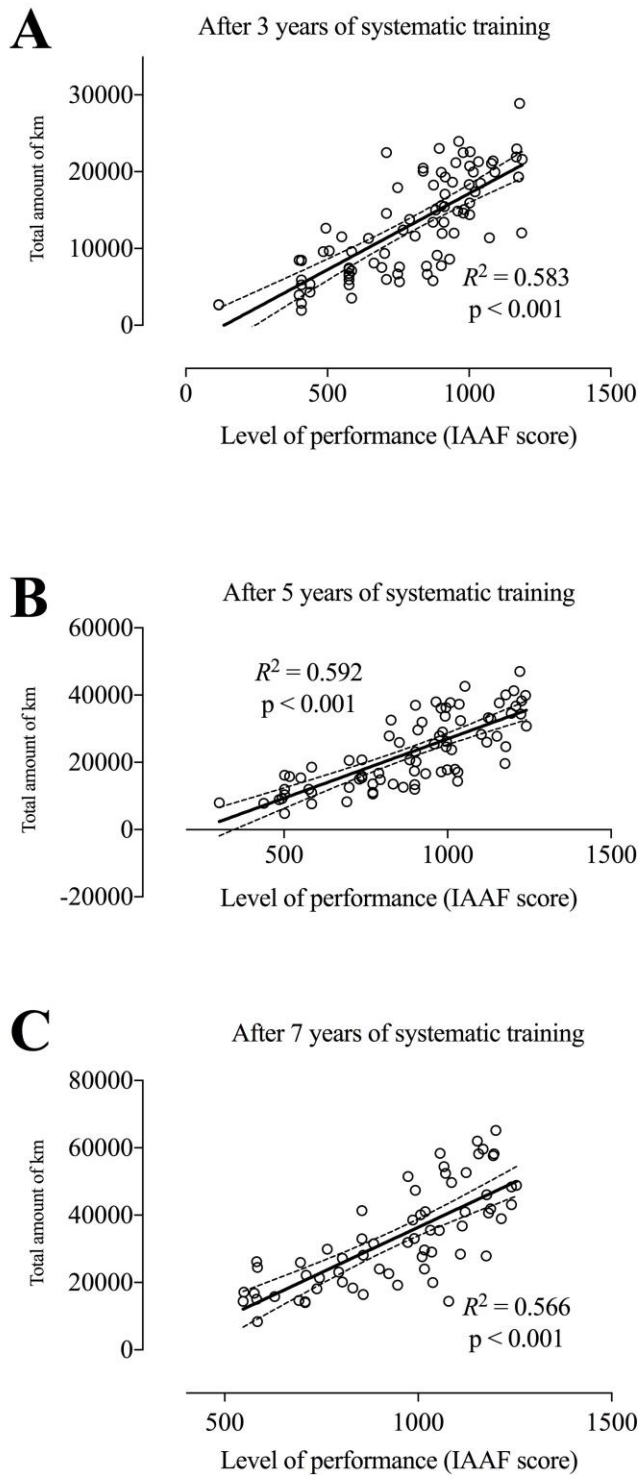
Figure 1. Simple linear regression analysis between performance and total distance after 3 years of systematic training (A), 5 years of systematic training (B) and 7 years of systematic training (C). R^2 = Pearson's multivariate coefficient of determination. IAAF = International Association of Athletics Federations.