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# Training Methods and Intensity Distribution of Young World-Class Rowers

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***Purpose:*** To describe the distribution of exercise types and rowing intensity in successful junior rowers and its relation to later senior success. ***Methods:*** 36 young German male rowers (31 international, 5 national junior finalists; 19.2 ± 1.4 y; 10.9 ± 1.6 training sessions per week) reported the volumes of defined exercise and intensity categories in a diary over 37 wk. Training categories were analyzed as aggregates over the whole season and also broken down into defined training periods. Training organization was compared between juniors who attained national and international senior success 3 y later. ***Results:*** Total training time consisted of 52% rowing, 23% resistance exercise, 17% alternative training, and 8% warm-up programs. Based on heart rate control, 95% of total rowing was performed at intensities corresponding to <2 mmol·L$^{-1}$, 2% at 2 to 4 mmol·L$^{-1}$, and 3% at >4 mmol·L$^{-1}$ blood lactate. Low-intensity work remained widely unchanged at ~95% throughout the season. In the competition period, the athletes exhibited a shift within <2 mmol exercise toward lower intensity and within the remaining ~5% of total rowing toward more training near maximal oxygen consumption ($VO_{2max}$) intensity. Retrospectively, among subjects going on to international success 3 y later had their training differed significantly from their peers only in slightly higher volumes at both margins of the intensity scope. ***Conclusion:*** The young world-class rowers monitored here exhibit a constant emphasis on low-intensity steady-state rowing exercise, and a progressive polarization in the competition period. Possible mechanisms underlying a potential association between intensity polarization and later success require further investigation.

***Keywords:*** high performance, training analysis, intensity distribution, endurance, rowing

Elite endurance athletes subject themselves to very high training loads in pursuit of maximal performance. For example, world-class senior rowers compete over a 2000-m distance requiring ~6 to 7 min, yet they invest a training volume in a season equivalent to many hours for each minute of an international competition. A key question that occupies the minds of athletes and coaches is how best to use this training investment. For numerous reasons, systematic intervention for

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research purposes is constrained in elite sport and experimental studies are lacking to identify any "optimal" training organization for maximizing both physiological and technical adaptations. We contend that the international competition environment is a quite effective experimental arena, in a Darwinistic sense. Extreme performance standards stimulate the emergence of self-organizing processes in which athletes, national teams, and governing bodies pursue the training structure that gives the most consistent success. This process, together with inter- and intraindividual method iteration, evaluation, and adjustments, presumably drives changes in training over time that correspond with continued performance improvements. For example, one of the major changes in the training evolution of international medal–winning Norwegian rowers over three decades was an increase in total training volume associated with a substantial shift in intensity distribution from higher to lower intensities.[1] Accurate descriptions of the training characteristics of highly successful athlete groups have value in furthering our knowledge about performance improvement in endurance sport and catalyzing experimental studies.

Also, within an elite athlete generation, fairly small improvements in performance may be critical to success.[2] Top performers approximate the margin of individual load tolerance in training, and minor variation in the balance of beneficial adaptation and maladaptive load-related stress reaction may account for critical differences in performance development. The day-to-day and seasonal distribution of training intensity appears to be a crucial variable in training organization for endurance athletes. Following the three-intensity zone structure representing exercise intensity below the first ventilatory threshold ($VT_1$; where the ventilatory equivalent for $O_2$ breaks from linearity, without an increase in the ventilatory equivalent for $CO_2$; typically < 2 $mmol \cdot L^{-1}$ blood lactate), from $VT_1$ to $VT_2$ (where the ventilatory equivalent for $CO_2$ also begins to increase; ~2 to 4 $mmol \cdot L^{-1}$), and above $VT_2$ (> 4 $mmol \cdot L^{-1}$),[3–5] it has previously been proposed that two basic intensity distribution patterns emerge from the research literature.[5,6] The "threshold training model" emerges from some short-termed studies demonstrating that training at the lactate threshold intensity evokes significant physiological improvements among untrained subjects.[7–10] A contrasting "polarized training model" has been proposed based on observations from a number of studies describing the distribution of work intensity among elite athletes in marathon running, rowing, track cycling, and cross-country skiing.[1,5,11–16] One consistent observation from these studies is that successful endurance athletes perform 75% or more of their training (sessions, distance, time) at intensities below $VT_1$. In addition, about 10% to 20% of training volume is reported to be clearly above $VT_2$, (ie, 6 to 10 $mmol \cdot L^{-1}$ blood lactate).[1,5,11,15,17] Consequently, remarkably little training is executed at the traditional lactate threshold. Thus, the training is apparently "polarized away" from the work range characterized by moderately hard intensity. If training intensity distribution is critical for optimal performance, we might expect to see quantifiable differences in organization between highly successful and less successful athletes with similar performance potential.

Recent longitudinal observations in quasi-experimental post hoc and experimental designs support the value of low-intensity training in achieving desired physiological adaptations and performance enhancement.[3,4,18,19]

In the current study, we extend these findings by reporting (1) a detailed description of the distribution of the exercise types and of the intensity distribution within the specific rowing workout, (2) their alteration over a complete training season from autumn until summer in a large group of internationally successful junior age rowers, and (3) a comparison of the training characteristics of the junior rowers who reached international senior finals 3 y later to those who did not attain this success level.

# Methods

## Study Design

The current study builds on the complete reported daily training data provided by 36 athletes from the men's German junior national rowing squad. This study was approved by the German Federal Institute of Sports Science including the subjects' informed, written consent for their training data to be used for research purposes.

All national squad members were requested to document their executed daily individual training in a standardized digital training diary and submit it to the national coach. Individual heart-rate (HR) ranges for defined intensity categories in training were determined during a centralized rowing ergometer ramp protocol (Concept CIIC; 3-min stages, 20-W steps) in the first week of each training year. In addition, rowing power (watts) at 4 mmol·L$^{-1}$ venous blood lactate ($P_{La4}$) was calculated from the blood lactate/rowing ergometer power relationship. The national rowing governing body did not perform standardized, centralized $VO_{2max}$ testing on junior rowers. Therefore, information regarding the maximal oxygen consumption of these athletes is not available. Individual HR ranges were prescribed for each of the rowing intensity categories based on the stable blood lactate–heart rate relationship determined during ramp protocol rowing ergometry performed at the beginning of the training season.[23] Heart rate was controlled during all rowing sessions via online HR monitoring (Polar, Kempele, Finland).

## Training Monitoring

Before the training, athletes were briefed as to the desired training composition by the coach and provided a reporting scheme. Training was categorized as defined by the national federation (see Table 1). The training data reported here represents the executed, not the planned, training for a complete training season (37 wk, $t_1$). In addition, competitive senior success for the entire sample was followed up 3 y later ($t_2$).

The intensity definitions used for training documentation closely correspond to the physiological three-zone model used in a previous study of rowing intensity distribution.[2] The categories *Compensation* and *Extensive Endurance* (<80% race pace; HR <160 b·min$^{-1}$; [La$^-$] <2 mmol·L$^{-1}$; Table 1) correspond with work below $VT_1$ ("zone 1"). *Intensive Endurance* (75% to 85% race pace; HR 156 to 168 b·min$^{-1}$; [La$^-$] 2 to 4 mmol·L$^{-1}$) corresponds with work intensity between $VT_1$ and $VT_2$ ("zone 2"). The categories *Highly Intensive Endurance*, *Race-Specific Velocity-Endurance*, and *Velocity Training* (85% to 112% race pace; HR >180 b·min$^{-1}$; [La$^-$] >4 mmol·L$^{-1}$) correspond with work intensity above $VT_2$ ("zone 3"). This three-intensity zone scheme has been previously described and used in both experimental and descriptive studies of endurance exercise intensity distribution.[5,20–22]

**Table 1 Category definitions for specific rowing training intensity as prescribed by the German national governing body in rowing**

| Category Label | Definition / Description | | | | | | |
|---|---|---|---|---|---|---|---|
| | Repetitions, duration (min) | Pause (min) | Total time (min) | Velocity (%$v_{race}$) | Stroke freq. ($n·min^{-1}$) | Heart rate ($b·min^{-1}$) | Blood lactate ($mmol·L^{-1}$) |
| Compensation | 1, 15–60 | | 15–60 | < 70 | < 20 | < 140 | < 2 |
| Extensive endurance | 1–3, 30–60 | 3–6 | 40–120 | 70–80 | ≤ 22 | 140–160 | < 2 |
| Intensive endurance | 2–4, 10–60 | 2–6 | 40–100 | 75–85 | 18–24 | 156–168 | 2–4 |
| Highly intensive endurance | 2–3, 3–10 | 10–20 | ≤ 90 | 85–100 | 24–34 | > 180 | 4–8 |
| Race-specific velocity-end. | 2–8, 0.7–2.0 | 5–15 | ≤ 70 | 95–110 | RF ± 4 | max | 4–6 |
| Velocity | 6–12, 0.2–0.4 | > 10 | | 106–112 | max | | |

*Note*. The first column's labels represent direct translations from the national governing body's documents (abbreviations: end. = endurance, freq. = frequency, RF = race frequency). Individual heart rates for targeted intensity ranges based on the lactate-HR relation during rowing ergometry.

Training was recorded from the beginning of the training season (15th October) until the national trials for the junior world championships (30th June; 37 wk in total). The 37 wk were divided into three training periods: basic preparation period (BPP) 1st to 15th training week, specific preparation period (SPP) 16th to 25th week, and (early) competition period (CP) 26th to 37th training week. The SPP culminated in the national small-boat championship regatta, which is obligatory for all squad members. The CP recording concluded with the national trials.

To evaluate the reliability of athletes' training documentation, diary figures reported to the national coach were compared with data reported directly to our research group (as "neutral" addressees) by 29 athletes participating in an anonymous postal survey after the referred season. Subjects were re-identified for this analysis based on birth date and success. The data from the training diary and from the postal survey correlated with $r = .88$ (training frequency; $P < .01$) and $r = .84$ (training time; $P < .01$). The diary figures deviated from those in the postal survey by 4.0 ± 8.5% in training frequency and –10.4 ± 12.3% in expended training time. No systematic relation between this deviation and performance achievement was observed ($P > .05$, in each case).

## Senior Success

The 36 athletes in this study continued rowing at a high level. We therefore retrospectively compared the junior training characteristics of 14 athletes who reached senior world championships and/or Olympic finals 3 y after the junior training registration period with the 22 who attained success "only" at national level within the same period.

## Statistical Analysis

All statistical analyses were performed using SPSS version 14.0. Physical, physiological, and training characteristics are presented as means and standard deviations. Training intensity distribution and other training characteristics were compared across the three defined training periods using repeated measures ANOVA. Comparison of the junior age training characteristics of internationally successful and less successful senior rowers was performed using independent samples *t* tests. A *P* value of < 0.05 was considered statistically significant.

# Results

All 36 athletes remained members of the national junior squad throughout the observed training period (2001; $t_1$) and became finalists at the national junior championships. Of these, 31 also reached the finals at the junior world championships, 27 attained a medal, and 15 became junior world champions. The athletes were 19.2 ± 1.4 y, 91.0 ± 6.0 kg, and 193.3 ± 5.3 cm at $t_1$. They performed a mean of 10.9 ± 1.6 training sessions and 12.8 ± 2.5 h of (net) training time per week. Their $P_{La4}$ value during rowing ergometry ramp protocol at the beginning of the training season was 373 ± 29 W. Three years after the training registration season ($t_2$), all 36 athletes were finalists at the national senior championships. Of these, 14 reached the finals at the Olympic Games (Athens 2004) and/or senior world championships, and 9 won medals.

Rowing-specific activities made up 52% of total junior training time (Table 2). The remaining 48% of training time was devoted to resistance exercise (23%); general athletic training, such as jogging, strengthening gymnastics, and game play (17%); and warm-up programs (8%). Strength training was dominated by "power endurance" training with high repetitions performed with moderate loads (76%). The overall distribution of rowing-specific training intensity is also provided in Table 2. Interestingly, ~95% of rowing-specific training was performed at intensities corresponding to < 2 mmol·L$^{-1}$ blood lactate (below $VT_1$, zone 1; *Compensation* and *Extensive Endurance* range).

Weekly training frequency increased from 10.3 ± 2.5 in the Basic Preparation Period (BPP) to 11.3 ± 1.7 in the Specific Preparation Period (SPP; $P < .01$) and was reduced again to 10.6 ± 1.8 sessions·wk$^{-1}$ in the (early) Competition Period (CP; $P < .01$). Figure 1 shows an approximate doubling in rowing-specific training volume from BPP to CP. This doubling was achieved via both an increase in total training volume and a decrease in strength training and alternative training. The relative contribution of low-intensity (zone 1) work to total rowing training remained almost constant throughout the entire season, but the higher-intensity work became significantly more intense (Figure 2). Low-intensity zone 1 endurance training made up 96% of all rowing volume during the BPP and only decreased to 94% in the CP. During the CP, there was also a small but significant shift within zone 1 rowing represented by a lowered volume of *Extensive Endurance* range (BPP 89%, SPP 88%; $P > .05$; CP 84%; $P < .01$) and an increase in the amount of very low intensity *Compensation* range rowing performed (BPP 7.1%, SPP 6.5%; $P > .05$; CP 10.1%; $P < .01$). The

**Table 2 Distribution of training by type and intensity for the entire 37-wk quantification period (mid-October until the end of June)**

| Distribution | Mean (SD) |
|---|---|
| **All Training** | |
| Frequency (sessions·wk$^{-1}$) | 10.9 (1.6) |
| Time (h·wk$^{-1}$) | 12.8 (2.1) |
| Rowing training (%) | 52.1 (5.1) |
| Resistance training (%) | 22.6 (4.3) |
| Alternative training (%) | 17.2 (5.2) |
| Warm-up and flexibility (%) | 8.1 (4.3) |
| **Rowing exercise** | |
| Time (h·wk$^{-1}$) | 6.6 (0.8) |
| Distance (km·wk$^{-1}$) | 97.1 (19.5) |
| Compensation range (%) | 8.1 (6.1) |
| Extensive endurance range (%) | 86.8 (6.3) |
| Intensive endurance range (%) | 2.0 (1.1) |
| Highly intensive endurance range (%) | 1.0 (0.4) |
| Race-specific velocity-endurance range (%) | 1.7 (0.6) |
| Velocity range (%) | 0.4 (0.5) |

*Note*. Percentage figures within rowing refer to the completed distance (km).

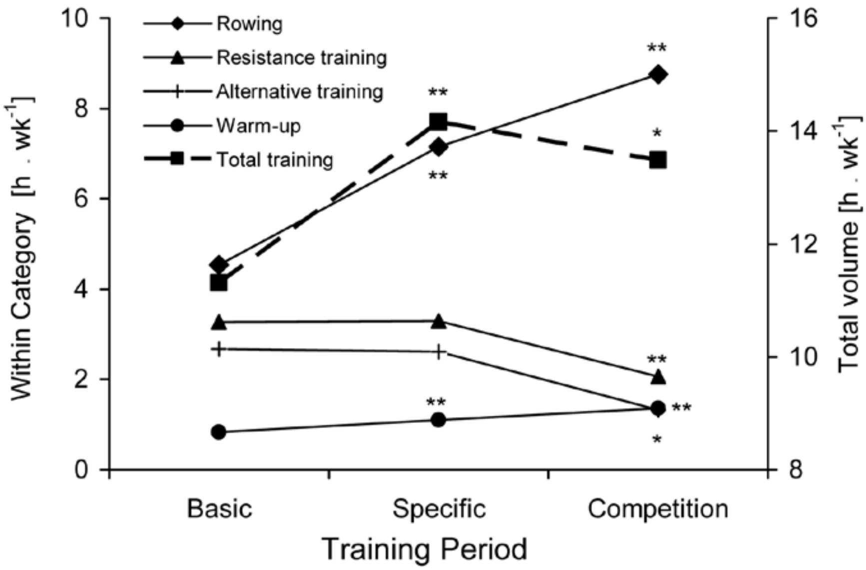


**Figure 1** — Volume (h·wk$^{-1}$) of total training and by training category in the basic preparation period, specific preparation period, and early competition period. Mean values (standard deviations omitted for clarity). *$P < .05$, **$P < .01$ vs previous period. *Note.* Total training volume values represented at 2nd ordinate.

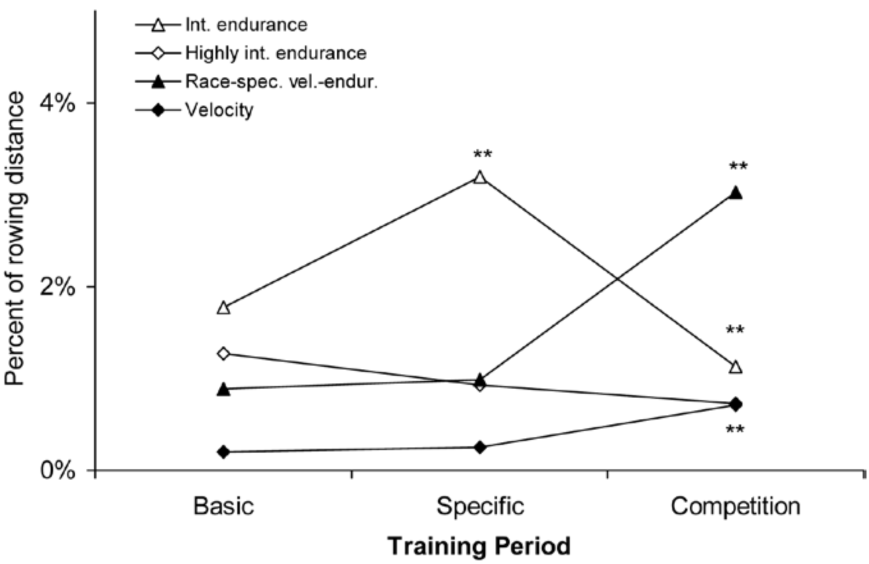


**Figure 2** — Proportions (rowing distance) of higher-intensity categories of rowing during the basic preparation period, specific preparation period, and early competition period. Mean values (standard deviations omitted for clarity). Int. = intensive, spec. vel. endur. = specific velocity endurance. Differences between periods: **$P < .01$ vs previous period. *Note.* All remaining rowing training was at extensive endurance or compensation intensity.

remaining 4% to 6% of rowing training distance shifted first toward a transiently higher volume of the *Intensive Endurance* range ("zone 2" lactate threshold intensity work) from BPP to SPP and then toward an enhancement of the highest-intensity ranges ("zone 3") of *Race-Specific Velocity-Endurance* and *Velocity* during CP (Figure 2). Whereas high-intensity training remained a small percentage of total training volume throughout the season, the 141% increase of the share of total rowing at race pace or higher intensity from BPP to CP ($P < .01$) represents an enhancement of the *absolute* distance rowed at this intensity range by about threefold.

Among 14 athletes who reached the finals at the Olympics and/or senior world championships 3 y after the training registration period ($t_2$) and 22 who did not, 12 (86%) and 19 (86%), respectively, had reached the finals at the junior world championships ($t_1$), 10 (71%) and 17 (77%) had medaled, and 5 (36%) and 10 (45%) had been junior world champions. The respective groups did not differ systematically in age (19.0 ± 1.3 and 19.4 ± 1.4 y; M ± SD), weight (91 ± 6 and 91 ± 6 kg), height (193 ± 5 and 193 ± 6 cm), or $P_{La4}$ (368 ± 28 and 376 ± 30 W) at $t_1$ (all $P > .05$).

Table 3 compares the junior-age training characteristics between internationally and nationally successful athletes. The rowers reaching international success as

**Table 3 Comparison of total training distribution among junior elite rowers with international (n = 14) and national success (n = 22) 3 y after the reporting period**

| | | International Success<br>Mean (SD) | National Success Only<br>Mean (SD) |
|---|---|---|---|
| **Total Training (37 wk)** | Sessions (n): | 401 (65) | 406 (61) |
| | Time (min): | 27,534 (3,119) | 28,966 (5,321) |
| Rowing Exercise | | | |
| Time (min) | | 14,654 (1,726) | 14,697 (1,999) |
| Compensation range (km) | | 422 (256) | 232 (177)* |
| Extensive endurance (km) | | 2,912 (446) | 3,236 (743) |
| Intensive endurance (km) | | 73 (43) | 74 (35) |
| Highly intensive endurance (km) | | 29 (12) | 40 (18) |
| Race-specific velocity-endurance (km) | | 67 (20) | 54 (17)* |
| Velocity range (km) | | 13 (11) | 15 (23) |
| Resistance Exercise | | | |
| Time (min) | | 6,226 (988) | 6,518 (1,751) |
| Alternative Training | | | |
| Time (min) | | 5,021 (2,593) | 4,873 (1,454) |
| Warm-up and Flexibility | | | |
| Time (min) | | 2,194 (1,519) | 2,520 (1,467) |

*Note*. Means ± standard deviations of quantities aggregated over 37 wk.
*$P < .05$.

seniors did not differ systematically ($P > .05$) as juniors in total training frequency or volume, distribution of expended training time, or their time distribution among different training modes. However, small but statistically significant differences were exhibited within the intensity distribution of their specific rowing endurance training. The international finalists completed more distance in both the lowest intensity *Compensation* range and the highest intensity *Race-Specific Velocity-Endurance* range.

## Discussion

An underlying premise for describing the training organization of highly successful athletes is that they are successful, in part, because of how they train. In this context, we believe the most important finding in this study is that, based on time-in-zone heart rate monitoring, internationally successful junior rowers performed 95% of all specific rowing training over a 37-wk training period in "zone 1," at a heart rate corresponding to a blood lactate concentration under 2 $mmol \cdot L^{-1}$. In comparison, the same time-in-zone, three-intensity zone method applied to a group of well-trained, nonelite distance runners showed that 71% of their training was in zone 1, 21% in zone 2, and 8% in zone 3.[3] Accepting that this well-established intensity quantification method tends to overestimate time spent at low training intensity,[5] these findings still demonstrate a marked emphasis on basic endurance training throughout the training season. In the present group of rowers, the 4% to 6% of rowing-specific training volume that was performed at higher intensity became more intensive as the season progressed, from emphasis on moderately high-intensity "lactate threshold" training, toward more race pace–intensity training at near $VO_{2max}$ intensity. That is, the intensity distribution became more polarized in the competition period.

This was a quite homogenous group of talented rowers who had reached national elite level in a very strong rowing nation. Their physique (mean 91 kg, 193 cm) clearly exceeded previously published descriptions of rowing finalists at junior world championships,[24] consistent with the fact that 15 of the subjects in the sample became junior world champions during the season training data were collected. The range in performance between "more successful" and "less successful" athletes as defined here is very small. In addition, this study did not compare effects of different training programs on performance and thus does not establish a causal relationship between intensity distribution and performance. It was an ex post facto analysis of common variation between characteristics of junior training and later senior success. Based on a 3-y follow-up analysis, the only significant difference in training volume or organization observed between the most successful and less successful rowers in this sample was a modest but significant increase in the degree of intensity polarization observed in the most successful athletes. Athletes who went on to senior international success had, as juniors, tended to perform slightly more of their total rowing endurance exercise at very low intensity and at very high intensity compared with their peers. We can only speculate what advantages this increase in intensity polarization might have provided. It might be that the increased polarization observed merely demonstrates a form of intensity management discipline (keeping hard training hard and easy training easy) among the most successful athletes that could prove protective against overstress.

The present findings are consistent with previous studies demonstrating that low-intensity (below $LT_1$ or $VT_1$) training dominates the total training volume of successful endurance athletes in a variety of sports.[1,11–16] However, the extreme emphasis on low-intensity, steady-state training seen in these elite junior rowers has not been reported in the research literature previously. The 2000-m rowing distance requires ~6 min to complete in a large team boat and is performed at 100% to 110% of $VO_{2max}$ intensity.[25] Clearly this distribution violates conventional wisdom regarding training intensity specificity; these athletes train relatively little at competition intensity. Recently, Ingham and colleagues compared 12 wk of training at low intensity only (98% of total training performed at <75% of $VO_{2peak}$) with a regimen of 70% low-intensity and 30% high-intensity training (>84% of $VO_{2peak}$). They found that in the British national standard rowers involved, both training regimes gave similar improvements in $VO_{2max}$ and rowing test performance, but that low-intensity-only training actually improved blood lactate responses at submaximal intensity to a greater extent.[19] No indicators of overreaching were present in the mixed intensity training group, making it unclear why the mixed training model failed to induce a greater performance improvement.

One of us has previously concluded that elite endurance athletes in running, cycling, cross-country skiing, and rowing often perform surprisingly little of their total training at intensities typically described as lactate threshold training, but instead tend to polarize their training away from this moderate intensity, training both a great deal at below $VT_1$ and a significant amount above $VT_2$ intensity.[22] The present descriptive study of internationally successful rowers and the recent experimental study on rowers by Ingham and colleagues[19] both suggest that marked performance adaptations and very high level performances in rowing can be elicited with a regiment of training that is dominated by low intensity, high volume work, with relatively little race pace, high-intensity training. These findings run contrary to accepted theories that substantial high-intensity training is critical for optimizing centrally limited oxygen delivery capacity in endurance athletes.[26,27]

Anecdotally, the training intensity distribution reported here is not unique to German rowers, but is also observed in other highly successful international programs. We propose that there are several unique characteristics of rowing specifically, as well as the elite training process in general that may explain the training distribution employed.

Expansion of total training volume generally is achieved at the expense of the high-intensity work proportion. High-performance athletes expose themselves to voluminous training load, mostly involving multiple daily sessions, and they approximate (at least temporarily) the margin of what is tolerable. Athletes attempt to balance loads evoking maximal positive adaptations (gene expression, synthesis of mitochondrial and other relevant proteins, cardiovascular performance, buffering capacity, technical efficiency at near race velocity) while avoiding excessive sympathetic stress leading to overtraining. Consistent with the evolution of training organization among international rowing medalists over recent decades and with reports from elite athletes in other endurance sports,[1,11–16] achieving this balance apparently favors the selection of a training intensity distribution characterized by voluminous low-intensity rowing below the lactate threshold with only intermittent highly intensive bouts.

Rowing power is a function of mean stroke force and stroke frequency. In trained rowers, peak forces during a rowing stroke remain quite consistent across rowing frequency,[28] with rowing stroke rate (ie, duty cycle) being the primary intensity control variable. We might speculate from this that extensive training at low intensities remains effective in recruiting a large proportion of available motor units, and achieves the specific muscular adaptations necessary to row at high power outputs as well. Elite rowers may therefore gravitate toward training below the first ventilatory threshold to stabilize technical aspects of the rowing stroke while still achieving desired physiological adaptations and perhaps avoiding excessive stress reactions.[22] It is also important to point out that although the relative percentage of high-intensity rowing was low, during the competition period, these athletes were still performing ~20 min of rowing weekly at heart rates corresponding to high intensity. Because a heart rate–based "time-in-zone" approach to intensity classification will tend to underestimate the actual time (and physiological stress) of rowing at high-work intensity owing to delays in heart rate responses, the actual high-intensity work duration each week is perhaps 30 min or more.

Rowing also differs from endurance sports like running and cycling in that substantial volumes of non-rowing training are performed. While almost all training time may be movement specific among road cyclists and distance runners, little more than 50% of the total training time of these rowers was rowing. Traditionally, rowing training often incorporates a significant strength training component, which reduced the relative time spent on rowing-specific training. Rowing ranged from 40% during the basic preparation phase to 65% of total training time during the early competition phase. Previously, it has been suggested that 70% of total training volume of rowers should be specific.[29] However, the lower value reported here is consistent with the fact that junior rowers often do not have the same access to good on-water conditions during the late fall and winter. In contrast, elite senior rowers are more likely to live in or travel to locations affording year-around access to on-water training.

Because a large proportion of total training volume in these elite junior rowers was not rowing, it is worthwhile to consider the impact of this training on the overall training intensity distribution of the rowers. Heart rate was not monitored during non-rowing activities such as stretching, game play, and jogging, but they were always performed at low intensity according to coaches and therefore would likely contributed almost exclusively to the low intensity volume. Strength training made up 23% of total training time. It is likely that some strength training sessions induced transient periods where local muscle metabolic rates and muscle and blood lactate values were consistent with training in zone 2 or zone 3. The potential contribution of this training to power output and fatigue resistance at race pace in rowing is unclear.

We contend that the reported observations prompt further research on training intensity distribution with particular attention to highly selective samples of extraordinary performers. Future goals are (1) to describe training load in more detail, including physiological responses and (2) to examine the effects of varying intensity distributions on physiological capabilities and performance.

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