Summary

Background: This study aimed to investigate the effects of playing strategies on match activities and physiological responses in well-trained female tennis players.
Materials and Methods: Twelve well-trained female players (25 ± 5 years) played points against an opponent of similar ability. Thereby, the players were instructed to apply either a passive, an active, or their own playing strategy. The latter consisted of free play and served as a control condition. During play, the stroking activities, activity profile, and running activities were investigated by video camera and global positioning system measures. Additionally, the physiological responses were examined through heart rate, capillary blood lactate, and visual analog scale procedures. The effects of the playing strategies were described as factors of the smallest worthwhile changes.
Results: The passive and active playing strategies had contrary effects on the match activities and physiological responses. The effects were more likely on the stroking activities and activity profile than on running activities and physiological responses.
Conclusions: Our study shows that playing strategies have an impact on match activities and physiological responses in well-trained female tennis players. This should be considered, when planning training drills for the players or analyzing match play data.

Keywords
Anaerobic – GPS – Magnitude-Based Inferences – Muscular power – Technical–tactical skills

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Effekte von Spielstrategien auf Spielaktivitäten und physiologische Beanspruchungen bei gut trainierten Tennisspielerinnen anhand eines alternativen statistischen Ansatzes

ORIGINAL PAPER / SPECIAL ISSUE

Effects of playing strategies on match activities and physiological responses in well-trained female tennis players derived by an alternative statistical approach

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Introduction

Tennis match play involves short (i.e., 5–10 s) repeated high-intensity running (i.e., accelerations, decelerations, and changes of direction) and stroking activities (i.e., strokes with different speeds, spins, and angles) over an unpredictable playing time (i.e., on average 1.5 h, but on male top-levels up to 6.0 h). The rules of the International Tennis Federation (ITF) mandate that these high-intensity periods are separated by recovery intervals of predefined duration (i.e., 10–20 s between points, 90 s between changeover, and 120 s between sets) [8]. Over the past 20–30 years, tennis has evolved into a highly physical demanding sport in both genders and all age groups [19]. Keeping pace with this progress requires specific training drills, for which comprehensive knowledge of match play data is essential [21].

In tennis, match play data have been investigated with respect to match activities and physiological responses. Match activities can be separated into data describing the stroking activities (e.g., service rates, number of winners and errors), activity profile (e.g., rally duration, effective playing time), and running activities (e.g., distances covered, acceleration measures) of the player. Physiological responses can be subdivided into data characterizing the cardiovascular (e.g., heart rate), hormonal (e.g., cortisol, testosterone), metabolic (e.g., oxygen uptake, blood lactate concentration), and subjective stress (e.g., rating of perceived effort) [12]. A plethora of studies are available, showing that numerous internal (e.g., age, playing level) and external factors (e.g. playing surface, thermal condition) have an impact on match activities

Zusammenfassung

Hintergrund: Ziel der Studie war es, die Effekte von Spielstrategien auf Spielaktivitäten und physiologische Beanspruchungen bei gut trainierten Tennisspielerinnen zu untersuchen.

Material und Methoden: Während Zwölf gut trainierte Spielerinnen (25 ± 5 Jahre) spielten Punkte gegeneinander aus. Dabei sollte entweder eine passive, eine aktive oder die eigene Spielstrategie (Kontrollbedingung) angewendet werden. Während der Spiele wurden die Schlagaktivitäten, das Aktivitätenprofil und die Laufaktivitäten mittels einer Videokamera und eines Global Positioning Systems erhoben. Ferner wurden die physiologischen Beanspruchungen anhand der Herzfrequenzen und kapillaren Blutlaktatkonzentrationen sowie einer visuellen Analogskala erfasst. Die Effekte wurden als relative Veränderungen im Verhältnis zur kleinsten lohnenswertesten Differenz ausgewertet.

Ergebnisse: Die passiven und aktiven Spielstrategien führten zu gegensätzlichen Effekte hinsichtlich der Spielaktivitäten und physiologischen Beanspruchungen. Die Effekte waren wahrscheinlicher bezüglich der Schlagaktivitäten und des Aktivitätenprofils als hinsichtlich der Laufaktivitäten und physiologischen Beanspruchungen.

Schlussfolgerungen: Die Studie zeigt, dass Spielstrategien einen Einfluss auf Spielaktivitäten und physiologische Beanspruchungen bei gut trainierten Tennisspielerinnen haben. Dies sollte im Rahmen der Trainingssteuerung und Spielanalyse berücksichtigt werden.

Schlüsselwörter
Anaerob— GPS— Effektgröße— Schnellkraft— Technisch-taktische Fertigkeiten

and physiological responses during play [8]. Since predominantly male tennis players were investigated in these studies, more research in females is required [7].

The tennis performance is complex and depends on interdepended relationships between anthropometric characteristics (e.g., height, body mass), physical capacities (e.g., muscular power, intermittent endurance), technical–tactical skills (e.g., stroke technique, ball placement), cognitive factors (e.g., self-confidence, anticipation), and medical aspects (e.g., orthopedic status, injury history) [12]. Due to the complex nature of tennis and inconsistent methods (e.g., testing procedures, playing levels), it is not possible to determine one key factor of performance [24]. However, supported by the impressions of top coaches, it is accepted that the technical–tactical skills predominantly determine the tennis performance [3,22]. With this in mind, it is surprisingly that the technical–tactical behavior of tennis players during matches is not studied very well [18].

In tennis, hierarchically superior to the technical–tactical behavior of the players are their playing strategies. While the technical–tactical behavior is variable (i.e., between or within rallies), playing strategies are predefined (e.g., developed by or with the coach), do not take the behavior of the opponent into account (i.e., self-referential), and thus, are fixed over a certain or the entire playing time (i.e., a strategic long-term behavior) [6]. Although playing strategies are barely defined in tennis [20], two contraire strategies can be observed in practice: a passive and an active strategy. To explain, the number of winners is only at top-levels comparable to that of errors. Thus, a common playing strategy to succeed is to reduce the own errors through a passive play from the baseline. The contraire strategy is to dominate the rallies by an active play, involving powerful topspin strokes at sharp angles across the full court. The goal of this strategy is to force the opponent to errors or to directly win the points by oneself [4,12,20].

To our knowledge, one previous study has investigated the effects of passive and active playing strategies on match activities and physiological responses in well-trained male tennis players [23]. Unfortunately, the study did not examine the effects on stroking and running activities. Thus, a study exploring the effects of playing strategies on comprehensive match activities and physiological responses is missing; particularly, in little studied females. Such a study may increase the understanding of playing strategies in tennis and match play data in females. From a practical point of view, such knowledge can help to optimize the physical capacities of the players via more specific training drills.

This study aimed to investigate the effects of playing strategies on match activities and physiological responses in well-trained female tennis players. Here, and to increase the transfer of our findings into practice, we investigated the effects by an alternative statistical approach – i.e., Magnitude-Based Inferences [2,11].

Material and methods

Participants and ethics statement

Table 1 shows the anthropometric characteristics, tennis backgrounds, and physical capacities of the 12 well-trained female tennis players that took part. All players were right-handed and "all-rounders", who preferred balanced combinations

Table 1. Anthropometric characteristics, tennis backgrounds, and physical capacities of the well-trained female players ($n = 12$).

Variable	Mean (90% CI)
Anthropometric characteristics	
Age (y)	25 (22–27)
Height (cm)	167 (164–170)
Mass (kg)	61.0 (58.9–63.1)
Fat (%)	22.4 (20.9–23.9)
Tennis backgrounds	
Regional ranking (1–23)	5.8 (4.2–7.3)
Tournaments per season (n)	18.8 (14.3–23.3)
Tennis training per week (n)	2.6 (1.9–3.3)
Physical training per week (n)	1.8 (1.6–2.1)
Physical capacities	
Maximal oxygen uptake (ml/kg/min)	40.9 (38.9–43.0)
Maximal heart rate (bpm)	190 (187–194)
Respiratory exchange ratio (VCO_2/VO_2)	1.22 (1.19–1.25)
Blood lactate (mmol/l)	10.3 (9.4–11.2)

Note: CI = confidence interval; VCO_2 = carbon dioxide excess; VO_2 = oxygen uptake.

of baseline play and attacking toward the net. The players were informed of the purposes, procedures, and potential risks of the study and provided written consent to participate. All of the procedures were accepted by the Ethics Committee of the University of Wuppertal (MS/JE 29.11.11) and were conducted in accordance with the Declaration of Helsinki.

Experimental design

Fig. 1 shows the experimental design of the study. All testing procedures were conducted on two sessions within one week during the last month of the outdoor season. On the first session, the players were examined in the laboratory for anthropometric measures, body composition using a bioelectric impedance analysis, and maximal oxygen uptake and heart rate on a motorized treadmill, as described in detail elsewhere [16]. On the second session, the players were tested on court. The data collection took place

on a red-clay court under ambient weather conditions (i.e., 20–26 °C and 38–45% humidity). After the players had warmed-up for 10 min with ground strokes, volleys, overhead strokes, and serves, they were asked to play points against an opponent of similar ability. The service changed after one player had served from both sides. During play, the players retrieved their own balls and counted the points. The players played three bouts of 10 min separated by 5 min rest periods. Before each bout, the players were instructed to apply either a passive, an active, or their own playing strategy to succeed. The instructions were given in an open manner (i.e., "try to win the points through a reduction of your own errors" and "try to force the opponent to errors or to directly win the points by yourself"). The bouts were played in a randomized order, whereas the bout with the own strategy was played first. This bout consisted of free play

and served as a control condition. During all bouts, both players applied the same strategy. The match activities of the players were investigated by video camera and global positioning system measures. The physiological responses were examined through capillary blood lactate methods and a visual analog scale for perceived effort at the beginning of the recovery periods. Additionally, heart rate data were assessed via short-range telemetry during play (Fig. 1).

Match activities

The stroking activities were investigated by a video camera (DCR-SR190, Sony, Tokyo, Japan) positioned 10 m behind the baseline at 10 m above the ground. Specifically, the number of double faults and ground strokes as well as relative rate of 1st services, winners, and errors were analyzed. The activity profile was also determined from the video. The number of rallies, strokes per rally, rally duration, rest time between the rallies, work to rest ratio, and effective playing time were assessed, as previously conducted in tennis [16]. All video analyses were performed using open-source software (Kinovea, version 0.8.15.) by a professional tennis coach.

The running activities were assessed and analyzed, as described in detail elsewhere [15]. Briefly, speed data were measured by a 10 Hz global positioning system (MinimaxX S4, Catapult Innovations, Melbourne, Australia). To eliminate noise, the speed data were proceeded by a Butterworth filter using a cut-off frequency of 1 Hz and two passes. From the filtered speed data, the total distance and distances with low (i.e., <3 m/s) and high speed (≥3 m/s) were computed. Additionally, the filtered speed data were deviated over
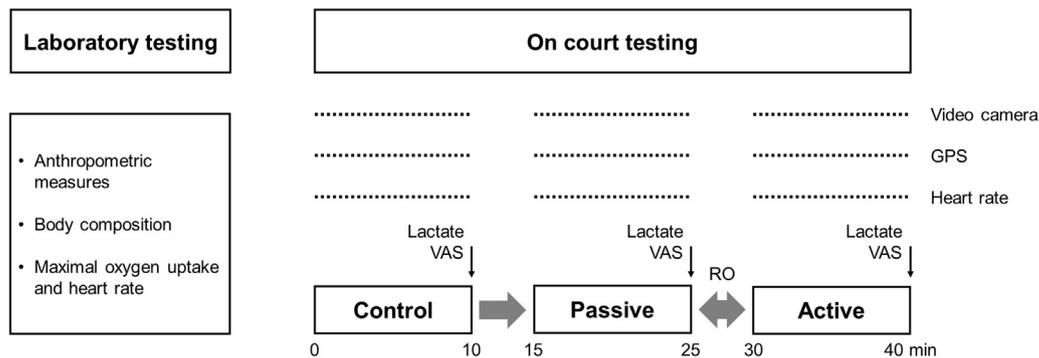
Figure 1
Experimental design of the study. *Note*: GPS = global positioning system; VAS = visual analog scale for perceived effort; RO = randomized order.

the time to derive acceleration and deceleration data. Therefrom, the distances with low (i.e., <2 m/s^2) and high acceleration (i.e., ≥ 2 m/s^2) as well as low (i.e., >-2 m/s^2) and high deceleration (i.e., ≤ -2 m/s^2) were computed. All thresholds were defined, as previously applied in tennis [13].

Physiological responses

The physiological responses were collected through heart rate, capillary blood lactate, and visual analog scale measures, as described in detail elsewhere [16]. The heart rate data were analyzed in relation to the maximal values achieved during the laboratory treadmill testing procedures and were considered as low (i.e., $<85\%$) and high (i.e., $\geq 85\%$), as previously applied in tennis [1].

Statistical analyses

Traditionally, the effects of playing strategies on match activities and physiological responses would have been investigated by null-hypothesis tests (i.e., here by *t*-tests for dependent samples or ANOVAs with repeated measures) and a software package (e.g., SPSS), producing *p*-values as outcomes. Thereon, and based on a predefined statistical

significance level (e.g., 5%), the null-hypotheses are either accepted or rejected. A limitation of this approach is that *p*-values are impacted by sample sizes (i.e., larger sample sizes lead to lower *p*-values). Consequently, small and non-meaningful effects can become statistically significant, when large sample sizes are used. Contrary, large and meaningful effects can result in non-significant outcomes, when sample sizes are too small; especially, being problematic in studies that investigate few participants of unique populations (e.g., elite athletes or patients with rare injuries) [11].

An alternative statistical approach is to focus on the magnitudes of the effects (e.g., absolute or relative differences) and their relations to the smallest worthwhile changes (SWCs) that are worth to be considered (e.g., reliability data of a technology, as the typical error or coefficient of variation). This approach called Magnitude-Based Inferences is independent of the sample size, aims to increase the transfer of findings into practice (i.e., practical before statistical significance) [2,11], and was computed here, as we have described in detail before [17]. Briefly, means and 90%

confidence intervals were computed first. Then, the dispositions of the confidence intervals for the effects (i.e., here computed as absolute differences) in relation to the SWCs (i.e., here defined by variability data) were examined. While the SWCs of the match activities were calculated from the pooled standard deviation multiplied by 0.2, the SWCs of the physiological responses were computed from the pooled standard deviations multiplied by 0.6 (i.e., the next effect size threshold according to Cohen's *d*). The different multipliers were used, because it is well known that physiological data show higher spontaneous variabilities than biomechanical data [10]. Finally, the probabilities for the effects "truly" being higher, similar, or lower than the SWCs were determined and qualitatively described using the following probabilistic scale: $<1\%$, most unlikely; 1 to $<5\%$, very unlikely; 5 to $<25\%$, unlikely; 25 to $<75\%$, possibly; 75 to $<95\%$, likely; 95 to $<99\%$, very likely, and $\geq 99\%$, most likely. If the probabilities of the effects for being both higher and lower than the SWC were $\geq 5\%$, the effects were described as unclear. To clarify the magnitudes of the effects, standardized differences

Table 2. Descriptive data for all assessed variables ($n = 12$).

Variable	Control Mean (90% CI)	Passive Mean (90% CI)	Active Mean (90% CI)
Stroking activities			
1st services (%)	69.8 (68.4–71.1)	72.0 (69.6–74.5)	68.7 (66.5–70.9)
Double faults (n)	2.3 (1.7–3.0)	1.3 (0.7–2.0)	3.2 (2.5–3.8)
Ground strokes (n)	53.7 (48.8–58.5)	121.0 (105.1–136.9)	45.2 (37.0–53.4)
Winners (%)	6.3 (4.8–7.9)	2.1 (1.5–2.7)	10.3 (9.2–11.5)
Errors (%)	28.4 (26.1–30.7)	12.7 (10.4–15.0)	40.6 (32.0–49.1)
Activity profile			
Number of rallies (n)	19.2 (18.4–19.9)	16.0 (15.2–16.8)	20.2 (19.3–21.0)
Strokes per rally (n)	4.7 (4.4–4.9)	9.7 (8.4–11.0)	4.1 (3.7–4.4)
Rally duration (s)	6.8 (6.4–7.2)	16.9 (14.3–19.5)	5.5 (4.9–6.2)
Rest time between rallies (s)	26.1 (24.6–27.5)	22.9 (21.2–24.7)	25.6 (24.1–27.1)
Work to rest ratio	3.9 (3.5–4.3)	1.6 (1.2–2.0)	5.0 (4.2–5.8)
Effective playing time (%)	21.4 (19.8–23.0)	42.8 (37.2–48.4)	18.2 (15.8–20.6)
Running activities			
Total distance (m)	396 (363–429)	423 (390–455)	397 (366–429)
Low speed (m)	392 (361–423)	418 (388–449)	392 (362–423)
High speed (m)	4 (1–6)	5 (2–7)	5 (4–6)
Low acceleration (m)	244 (225–263)	262 (240–284)	245 (226–265)
High acceleration (m)	11 (9–13)	18 (16–20)	12 (9–14)
Low deceleration (m)	115 (102–128)	116 (105–126)	116 (105–127)
High deceleration (m)	5 (4–7)	6 (5–7)	5 (4–6)
Physiological responses			
Low heart rate (s)	400 (317–483)	328 (248–408)	447 (376–518)
High heart rate (s)	210 (130–291)	292 (211–372)	169 (99–239)
Blood lactate (mmol/l)	1.8 (1.5–2.2)	2.3 (2.0–2.7)	1.5 (1.3–1.7)
Rating of effort (0–100)	23 (14–31)	36 (22–49)	34 (23–44)

Note: CI = confidence interval; see text for further details.

labeled as effect sizes (i.e., Cohen's *d*) were calculated and interpreted accordingly: 0.2 to <0.6, small; 0.6 to <1.2, moderate; 1.2 to <2.0, large; 2.0 to <4.0, very large; and ≥4.0, extreme large.

Results

Table 2 summarizes the descriptive data for all assessed variables. Fig. 2 shows the effects of playing strategies on match activities and physiological responses based on the alternative statistical approach.

The effects are presented as factors of the SWCs together with the corresponding effect sizes and probabilities for being "true". Compared to the control condition, the playing strategies have up to most likely effects on the stroking activities (−14.6 to 12.5-fold of the SWC) and activity profile (−13.1 to 12.4-fold of the SWC). The corresponding effect sizes were up to very large ($d \le 3.1$). The effects on the running activities (−0.4 to 7.2-fold of the SWC) and physiological responses (−2.6 to 3.0-fold of the SWC) were predominantly unclear,

with exception of some data (i.e., high acceleration, deceleration, and heart rate, blood lactate and rating of effort) for which up to most likely effects (1.1 to 7.2-fold of the SWC) with large effect sizes ($d \le 1.5$) were observed.

Discussion

This study aimed to investigate the effects of playing strategies on match activities and physiological responses in well-trained female tennis players. Our main findings
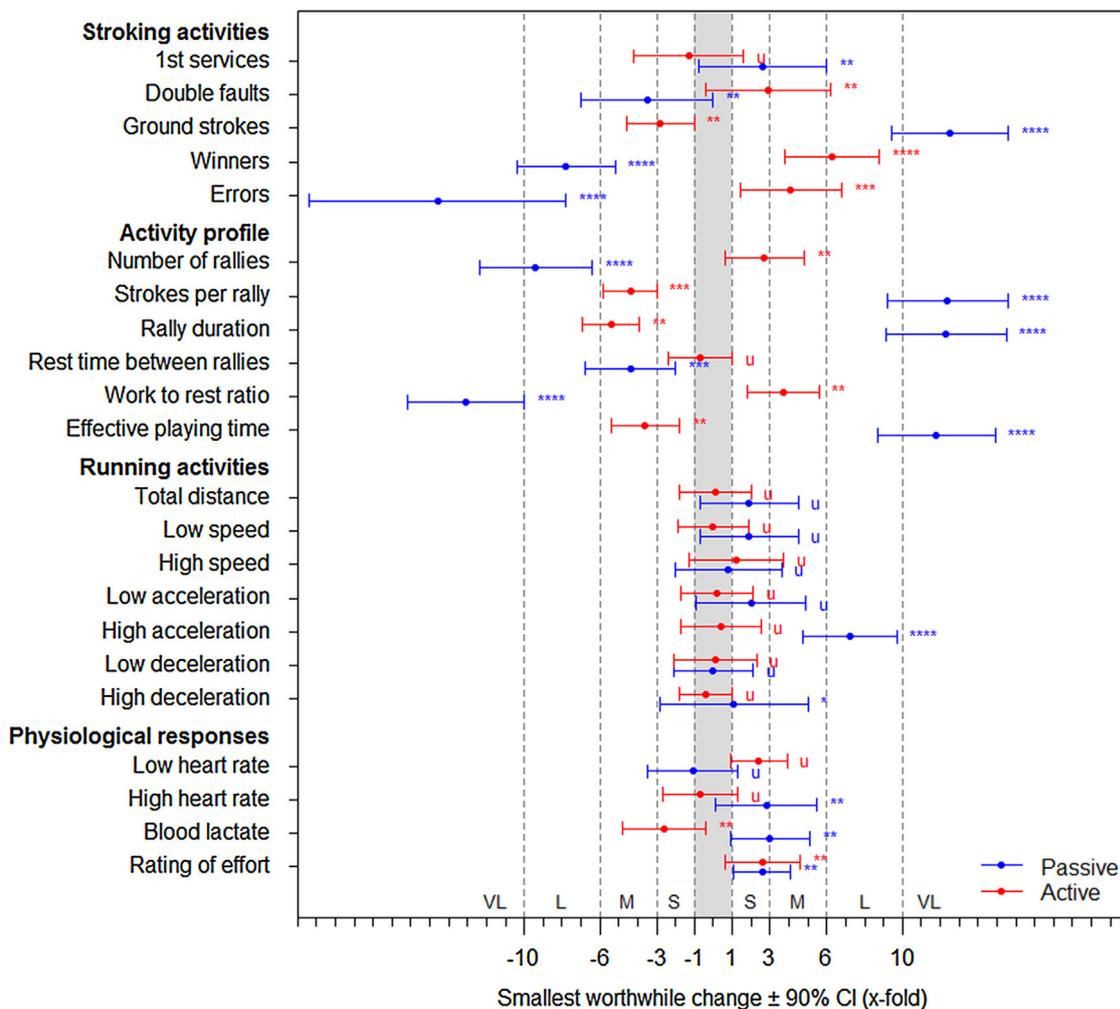
Figure 2
Effects of playing strategies on the match activities and physiological responses in well-trained female tennis players (*n* = 12).
Note: Each effect is shown as factor of the smallest worthwhile change (SWC). The corresponding effect size thresholds for small (S; ±1-fold), moderate (M; ±3-fold), large (L; ±6-fold), and very large effects (VL; ±10-fold) are also shown. The asterisks *, **, ***, and **** indicate the probabilities that the effect is possibly (>75%), likely (>90%), very likely (>95.5%) and most likely (=100%) higher or lower than the SWC. The letter u indicates an unclear effect with probabilities of ≥5% that the effect is both higher and lower than the SWC. See text for further details.

were: (1) passive and active playing strategies have contrary effects on the activity profile, stroking and running activities, and physiological responses; and (2) the effects were more likely on the stroking activities and activity profile than on running activities and physiological responses.

In tennis, playing strategies [20] and females [7] are little studied. One previous study has investigated the effects of passive and active strategies on match activities and physiological responses in well-trained male players [23]. The study shows that a passive strategy leads to longer rally durations and effective playing times and higher heart rates and blood lactate concentrations (all *p* < 0.01) than an active strategy. These findings are in line with our data in well-trained female players (Table 2 and Fig. 2). Since we have

additionally investigated the effects on running and stroking activities, our study increases the understanding of playing strategies in tennis and match play data in females. Our outcomes may have practical applications, as discussed below.

Our first major finding was that passive and active playing strategies have contrary effects on the activity profile, stroking and running activities, and physiological responses
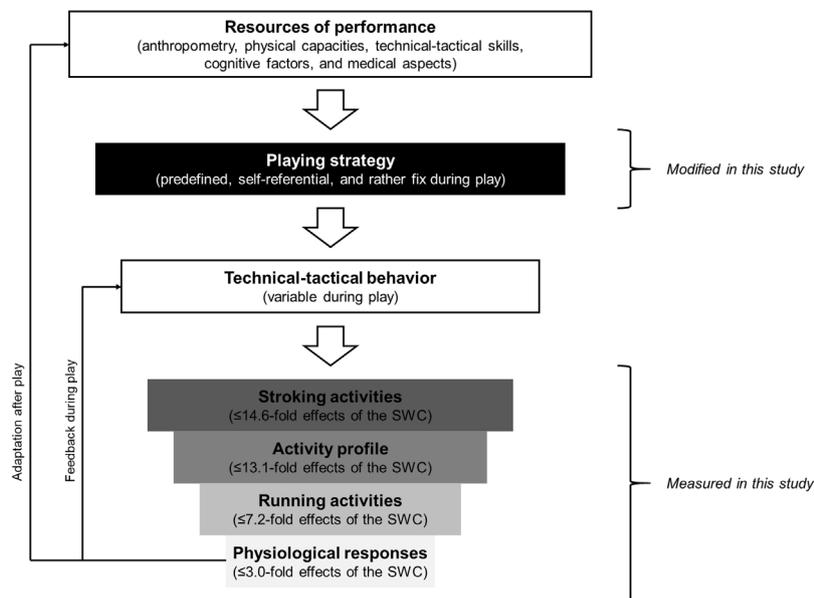
Figure 3

Working model concerning the relationships between resources of performance, playing strategies, technical–tactical behavior, and match activities and physiological responses in tennis. *Note*: **From an integrative exercise physiology perspective, the physiological responses (e.g., heart rates) of the players are continuously integrated into their afferent feedback during play. Accordingly, and in consideration of their resources of performance (e.g., maximal oxygen uptake) and experiences (e.g., to play at low, moderate, or high temperatures), the technical–tactical behavior of the players may change in a feed-forward manner (e.g., by performing a winner stroke to finish the rally to avoid fatigue). Moreover, the physiological responses may induce long-term adaptations after play, which may lead to changes in resources of performance (e.g., in maximal oxygen uptake), playing strategies (e.g., toward a more passive or active strategy), technical–tactical behavior (e.g., in ball placements), and finally match activities (e.g., in rally durations) and physiological responses (e.g., in heart rates). SWC = smallest worthwhile changes. See text for further details.**

(Table 2 and Fig. 2). Although playing strategies are barely investigated in tennis [20], the findings were expected from observations in the field. The contrary effects of the strategies may be caused by their opposed technical–tactical attributes [4,20]. In fact, the passive strategy can be described by: (i) predominantly playing from the baseline without net attacks; (ii) constantly playing into the center of the court; (iii) avoiding sharp angles and changes in angles for minimizing lateral errors; and (iv) reducing ball speeds and increasing ball spins for minimizing errors of depth and into the net. In contrast, the active strategy may be linked to: (i) variably playing from the baseline with net attacks; (ii) playing across the full court dimensions; (iii) playing with sharp angles and changes in angles; and (iv) increasing ball speeds and decreasing ball spins for playing close to the baseline [12]. Noteworthy, an exception of the contrary effects was that both playing strategies increased rating of perceived efforts (Table 2 and Fig. 2). Although the underlying reasons remain unsolved here, cognitive causes (e.g., during known and unknown playing situations)

are reasonable to assume, requiring more research. Additionally, we found that the passive strategy having more likely effects than the active strategy (Fig. 2). This means, that the active strategy is more similar to the control condition (i.e., free play) than the passive strategy. An explanation may be related to the playing level of our players. It can be speculated that our well-trained players rather prefer an active strategy during their competitions. This may be not the case in less-trained players, who are potentially not skilled enough for an active strategy (e.g., to play with powerful topspin strokes at sharp angles across the full court) [14]. To clarify these speculations, and also the relationships between both playing strategies and success in tennis (i.e., match outcome or ranking), more research across different playing levels is required.

The second major finding was that the effects were more likely on the stroking activities and activity profile than on running activities and physiological responses (Fig. 2). These outcomes support the assumed relationships between playing strategies and technical–tactical behavior, as introduced here before [6]. With this in mind, it can be expected that tennis players select strategies to succeed based on their individual characteristics in key factors (i.e., resources [9]) of performance [12]. During play, the technical–tactical behavior is then modified accordingly [6]; however, it is noteworthy that the technical–tactical behavior is difficult to operationalize [18]. Nevertheless, based on the maximal effects observed here (Fig. 2), it can be hypothesized that modifications in the technical–tactical behavior firstly manifests in differences in stroking activities, which then lead to differences in the activity profile,

running activities, and finally physiological responses. Fig. 3 shows a corresponding working model in regards to the relationships between resources of performance, playing strategies, technical–tactical behavior, and match activities and physiological responses in tennis. A further explanation of our findings may be that running activities and physiological responses were rather globally investigated. Thus, more research to validate the model via more specific approaches regarding running activity (e.g., with respect to on-court movement directions [14]) and physiological analyses (e.g., on micro RNA levels [16]) is required.

To investigate the effects of playing strategies on match activities and physiological responses, we applied an alternative statistical approach – i.e., Magnitude-Based Inferences [2]. A strength of this approach is that effects can be described according to their magnitudes (i.e., small, moderate, large, or very large) and distinguished with corresponding probabilities into: (i) trivial effects (i.e., the effect is within the SWC); (ii) clear positive or negative effects (i.e., the effect is higher or lower than the SMC); and (iii) unclear effects (i.e., the effect is both higher and lower than the SMC). Such outcomes may help to transfer empirical findings into practice via strong statements [5,11], for example: "*In well-trained female tennis players, a passive playing strategy leads to largely more distances covered at high acceleration. This effect is clear and has a probability of 100% for being higher than the SWC*" (Fig. 2). These outcomes cannot be compared with those derived by traditional null-hypothesis tests (i.e., *p*-values), because *p*-values solely specify, whether hypotheses (e.g., "*that a passive playing strategy does not lead to more distances covered at high acceleration*") are rejected or accepted

[11]. A weakness of Magnitude-Based Inferences is that the SWC must be defined [5]. Therefore, no standardized procedure exists; however, more (i.e., based on variability data as applied here, technical errors derived by reliability studies, or data reported in meta analyses) and less objective methods (i.e., based on own practical experiences) are available, requiring more research [5].

From a practical and physical point of view, our outcomes suggest that training drills in tennis should consider the playing strategies of the players; especially, during the pre-season or rehabilitation (e.g., after shoulder injuries, as discussed in a further article of the present journal issue). In fact, our findings suggest that a passive strategy may place higher aerobic and anaerobic-lactic (e.g., shown by the more conducted ground strokes, longer effective playing times, more distances covered at high acceleration, and higher lactate concentrations) and cardiovascular demands (e.g., shown by longer times spend at high heart rates) on the players, whereas an active strategy may require higher muscular power (e.g., shown by the more conducted winners) and anaerobic-alactic demands (e.g., as shown by the higher work to rest ratio) (Table 2 and Fig. 2). Consequently, in players favoring the passive strategy, training drills should focus more on endurance associated capacities. Contrary, for the active strategy, the attention should rather be placed on muscular power related capacities. Additionally, our study suggests that playing strategies must be considered as an up to very large impacting factor on match play data in tennis, which has not sufficiently been considered so far.

In conclusion, based on an alternative statistical approach, our study shows that playing strategies have

an up to very large and most likely impact on match activities and physiological responses in well-trained female tennis players. Thus, playing strategies should be considered, when planning training drills for the players or analyzing match play data. More research to understand the relationships between resources of performance, playing strategies, technical–tactical behavior, and match activities and physiological responses in tennis is needed.

Conflict of interest

Acknowledgments

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