

[Athletic Training]

Volume-based Interval Training Program for Elite Tennis Players

Natalie L. Myers, MS, ATC, PES[†], Aaron D. Sciascia, MS, ATC, PES[‡],
W. Ben Kibler, MD, FACSM[‡], and Tim L. Uhl, PhD ATC, PT, FNATA[†]

Background: A sport-specific conditioning program can help tennis players train for competition or return to play from injury. This study determined the actual tennis serve volume in elite play and used these data to construct an interval training program based on stroke volume.

Hypothesis: There will be no differences in serve volume between male and female tennis players at the professional and junior levels.

Study Design: Retrospective cohort study.

Level of Evidence: Level 3.

Methods: Game day statistic scorecards were provided to the research team from the 2013 and 2014 United States Open and the 2014 Metropolia Orange Bowl International Tennis Championships. Serve volume data for both male and female players were extracted from the scorecards. Data included serves per match and per set. These data were used to construct a sport-specific tennis program to meet the demands of the serve.

Results: Professional male players serve 63 more serves per match than junior male players because of the greater number of sets played ($P < 0.01$). Professional female players serve 10 more serves per match than junior female players playing the same number of sets ($P = 0.01$). All male players hit 2 more total serves per set than all female players ($P < 0.01$). Regardless of sex, professional players serve 4 more serves per set than junior players ($P < 0.01$). The typical number of serves per set was 40 in elite-level tennis players, resulting in a 3:1 ratio of first to second serves.

Conclusion: These data establish the “unit dose” of serves per match and/or per set for each group.

Clinical Relevance: Coaches and health care providers may use these data in estimating loads per tournament/season and to prepare tennis athletes for individual competition and/or as they return to play after an injury.

Keywords: serve volume; interval training program; elite tennis players; training; return to sport

Tennis is a global sport played by many players at multiple skill levels. The term “elite tennis player” describes professional and competitive junior players. These players undergo rigorous schedules resulting in high tournament exposure with the possibility for increased injury risk; therefore, optimal conditioning and training programs should be incorporated into training. Epidemiological studies show upper extremity injuries range between 20% and 49% of total injuries, with shoulder and elbow injuries accounting for 12% to 17% and 6% to 20%, respectively.^{6,7,12-14,16} In combination with other

factors, the repetition of high biomechanical stresses may play a role in these injuries. Youth baseball research has suggested that there is a relationship between shoulder and elbow injuries with pitch volume.¹¹ The volume of throws during a baseball game at all levels has been monitored to develop throwing volume training guidelines aimed at assisting coaches and health care providers (HCPs) in preparing baseball players for the demands of the sport.^{1,2} As a result, athletes are able to appropriately train for competition, and if injured, return to preinjury activity levels using a stepwise progression to increase the volume of throwing.

From the [†]Department of Rehabilitation, College of Health Sciences, University of Kentucky, Lexington, Kentucky, and [‡]Shoulder Center of Kentucky, Lexington Clinic Orthopedics-Sports Medicine, Sports Medicine Center, Lexington, Kentucky

*Address correspondence to Natalie L. Myers, MS, ATC, PES, 210c Charles T. Wethington Building, 900 South Limestone, Lexington, KY 40506-0200 (email: natalie.myers@uky.edu).

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Currently, the only known metric specific to the volume of tennis serves is that male professional players serve approximately 8 times during a single game.⁸ However, typical serve volume for female professional players and elite juniors during a set and match are unknown. Knowledge of serve volume can help coaches and HCPs train athletes to meet the specific demands of tennis. Therefore, the purpose of this research was 2-fold: to determine the typical volume of serves per set and match at 2 different levels of elite players: professional and junior. It was hypothesized that there would be no differences in serve volume between male and female tennis players at the professional and junior elite levels. The goal of this research was to develop a volume-based interval training program for elite-level tennis players.

METHODS

Data Acquisition

A retrospective review was performed to investigate the mean number of serve attempts during a match and per set. The research team received a waiver of consent from the University of Kentucky's Institutional Review Board prior to recording any data. Authors defined "elite level" as professional players competing in the United States Open Championships (US Open) and juniors competing in the Metropolia Orange Bowl International Tennis Championships. Analysis was performed on the 2013 and 2014 US Open and the 2014 Orange Bowl. Participants included 135 men and 122 women who ranked in the top 200 at the start of January 2013 and 2014. Junior player data included 134 boys and 136 girls between the ages of 13 and 18 years. Data were excluded if players retired from match play.

Serve Volume: Data Management

Serve volume data were extracted for both the professional and junior players from game day match statistic summaries. The numbers of first and second serves per set were extracted for all professional players, allowing calculation of the number of serves during a set and match. The same variables were extracted for all junior players with the exception of the number of second serves per set, as it was not available from the scorecards. However, the total number of second serves per match could be extracted from the juniors' data. This variable estimated the serves per set by dividing the total serves during a match by the number of sets played by each junior player.

For the purposes of this project, the 2013 and 2014 professional data were combined. If the player participated in several matches during 1 tournament, the median value was calculated to represent typical serve volume. The median values were then averaged and used to represent final values for each of the dependent variables.

Interval Training Program: Data Management

Strokes included in this program were forehands and backhands, first serves, and second serves. This study did not directly count

the number of groundstrokes; however, previous research has recorded the number of groundstrokes and that was utilized in developing this program.⁸ A stepwise progression model incorporating undulating periodization was utilized.

Statistical Analysis

Three dependent variables were extracted from both the professional and junior game statistic summaries for statistical comparison: (1) total match serve volume, (2) number of first serves per set, and (3) total serve volume per set. The Shapiro-Wilk test confirmed all data were normally distributed ($P > 0.05$). A 2-way analysis of variance determined differences between male and female players at their respective level of play.

The number of second serves per set could only be extracted from the professional data. An independent *t* test was run to determine differences between sexes at the professional level. All data were analyzed using Statistical Package SPSS version 21 (IBM Corp). An α level of $P \leq 0.05$ was considered significant.

RESULTS

Male and female professional tennis players serve more serves during a match compared with male and female junior players (Figure 1). There were significant main effects for level of play and sex for serve volume per set (Table 1). Male players serve more first serves per set (30 ± 5) than female players (29 ± 5) ($P = 0.01$), regardless of the level of play. Regardless of sex, professional players serve more first serves per set (30 ± 5) than junior players (29 ± 5). There are no differences between the number of second serves per set in professional male (13 ± 3) and female (12 ± 3) players ($P = 0.06$).

Program Design

The program was constructed with 2 variables in mind based on the results of this study and a previous study.⁸ The first variable is that players serve approximately 40 serves per set, resulting in a 3-to-1 ratio (for every 4 serves, 3 should be first serves and 1 should be a second serve). In most tournaments, the maximum number of sets is 3; therefore, 120 serves per match was the end target for this program. The second variable is that players hit approximately 7 groundstrokes per game regardless of whether they are serving.⁸ The mean number of games per set is estimated to be 10,¹⁵ indicating that a player will hit on average 70 groundstrokes per set or 210 groundstrokes per match. Consequently, a 21-step progression was devised to prepare players for approximately 120 serves and 210 groundstrokes per match. The program is divided into 3 phases (Table 2). The goals and volume progression for each phase are presented in the Appendix (available at <http://sph.sagepub.com/content/by/supplemental-data>). Program progression guidelines were adopted from Axe et al² (Tables 3 and 4).

DISCUSSION

These data provide serve volume parameters based on the highest level of tennis competition for both professional and

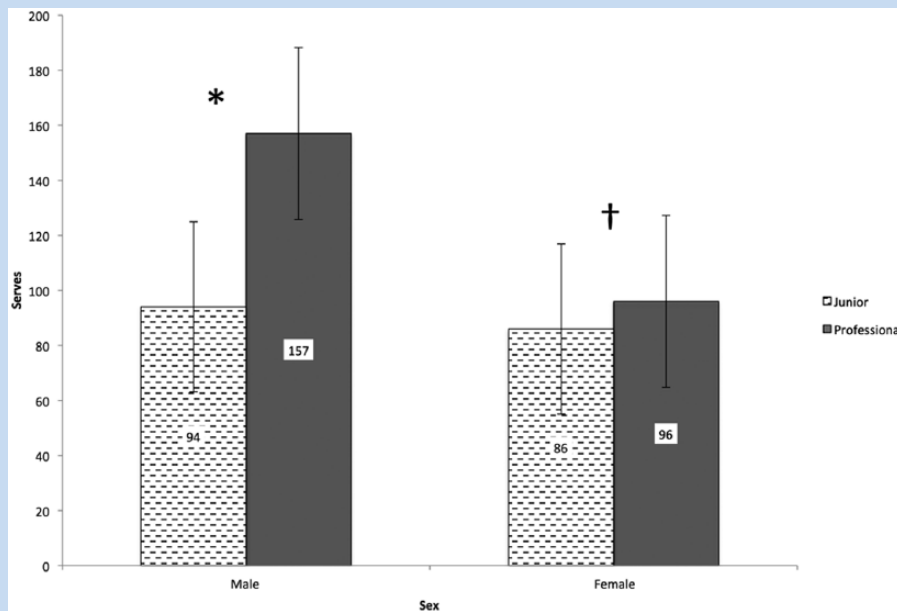


Figure 1. Total serve attempts during a match for both male and female junior and professional players. *Difference between male professional and junior tennis players, $P < 0.01$. †Difference between female professional and junior tennis players, $P = 0.01$.

junior tennis players. In addition, this study has established specific “doses” of serves per set for elite tennis players (approximately 40 serves). Training players should include “doses” of serves that replicate match situations. This dose, when multiplied by the anticipated number of sets to be played, can estimate the load on the body.

Since the tennis serve is similar to the pitching motion in baseball, the comparison may be made on the volume of overhead activity between these 2 sports. Since cumulative match statistics for tennis are not as readily available as they are for baseball,⁴ assumptions were made to determine the volume of serves over a competitive tennis season. Male and female players average 45 matches of 3 sets per match per season, resulting in 135 sets played. Players are hitting on average 40 serves per set, thus accumulating 5400 serves during a competitive season. In contrast, a Major League Baseball pitcher averages 2655 pitches during a competitive season.^{2,4} Although there are no data relating this number of serves with injury, inferences from baseball would suggest concern about injury risk.

Stroke production during a tennis match requires the generation of repetitive forces and motions, exposing the body to high stress, especially during the tennis serve.⁹ Exposure to these stresses during the serve is inevitable, yet an interval training program may be one component of a protocol to help players successfully return to tennis play after an injury or prepare for the demands of the serve prior to or after competition.

An interval training program can be used in conjunction with conditioning and rehabilitation programs to help progress the athlete back into the demands of the sport.^{2,5} This program is based on previously published literature,^{1,2,3,5} incorporating burst of intensity throughout the stepwise progression while following previously designed soreness and injury classification rules throughout the progression. This program differs, however, in that volume and intensity never increase at the same time.

This particular program is based on the typical number of serves and groundstrokes⁸ an elite player achieves. This program is preliminary, and future work should establish its validity. It has several limitations. Serves hit during practice sessions were not recorded. Thus, the estimates do not include the total number of serves hit during the entire competitive season. These data only included serve volumes from 2 tournaments; however, both the US Open and the Orange Bowl are considered the highest levels of tennis competition. Last, the data were not collected prospectively over the course of a season, yet seasonal serve volume was estimated based on the mean number of sets played over a season. Finally, the interval training program only addresses stroke volume; it does not take into consideration types of strokes practiced.

CONCLUSION

When training elite tennis players, both coaches and HCPs should use a 3-to-1 ratio regarding serves. The interval training program incorporates serve volume parameters based on the

Table 1. Total serve volume per set across sex and across level of play^a

Level of Play	Male	Female	P Value	Mean Value
Professional	43 ± 8	42 ± 7	—	43 ± 8
Junior	40 ± 8	38 ± 8	—	39 ± 8
Mean value	42 ± 8	40 ± 8	<0.01	P < 0.01

^aData presented as mean ± standard deviation.

Table 2. Elite-level tennis players' interval training program

Phase	Step	Ground Strokes	Ground Stroke Intensity, %	Serve	Serve Intensity, %	Total Stroke Volume	Games Played	First Serves per Game	Second Serves per Game	Ground Strokes per Game
1	1	10	50	—	—	10				
	2	10	50	2 ^a	50	12				
	3	10	50	3 ^a	50	13				
	4	12	50	4 ^a	50	16				
	5	12	50	6 ^a	50	18				
2	6	14	60	8	60	22	2	6	2	7
	7	18	60	10 ^b	60	28				
	8	22	60	12 ^b	60	34				
	9	26	60	14 ^b	60	40				
	10	28	60	16	60	44	4 ^c	6	2	7
3	11	28	80	16	80	44	4 ^c	6	2	7
	12	42	80	24	80	66	6 ^c	6	2	7
	13	56	80	32	80	88	8 ^c	6	2	7
	14	42	90	24	90	66	6 ^c	6	2	7
	15	56	90	32	90	88	8 ^c	6	2	7
	16	84	90	48	90	132	10 ^c	10 ^d		8 ^e
	17	112	90	64	90	176	12 ^c	11 ^d		9 ^e
	18	56	100	32	100	88	8 ^c	6	2	7
	19	168	100	96	100	264	14 ^c	14 ^d		12
	20	224	100	128	100	352	16 ^c	12	4	14
	21	Simulated Match								

^aAll second serves.

^bCombination of first and second serves.

^cRest 90 seconds after 2 games.

^dTotals do not add up to serve column because of rounding, mathematically inappropriate to use a ratio of first to second serves.

^eTotals do not add up to ground stroke column because of rounding.

Table 3. Soreness rules^a

1. If no soreness, advance 1 step every stroke training day.
2. If sore during warm-up but soreness is gone within the first 15 strokes, repeat the previous workout. If shoulder becomes sore during this workout, stop and take 2 days off. On return to stroke training, drop down 1 step.
3. If sore more than 1 hour after hitting or the next day, take 1 day off and repeat the most recent stroke training workout.
4. If sore during warm-up and soreness continues through the first 15 strokes, stop playing and take 2 days off. On return to playing, drop down 1 step.

^aAdapted from Axe et al.²Table 4. Injury classification^a

Nonserving arm injury	After medical clearance, begin with step 1 and advance 1 step daily, following soreness rules and performance capability
Serving arm injury: bruise or bone involvement	After medical clearance, begin with step 1 and advance every other day, following soreness rules and performance capability
Serving arm injury: tendon/ligament (mild)	After medical clearance, begin with step 1 and advance program to step 6 every other day, following soreness rules; advance program as soreness rules allow until the end of the program
Serving arm injury: tendon/ligament (moderate, severe)	After medical clearance, begin with step 1. For steps 1-6, advance no more than 1 step every 3 days, with a day of active rest ^b after each workout day. For steps 7-18, advance no more than 1 step every 3 days, with 2 days of active rest after each workout day. Advance program following soreness rules and performance capability

^aAdapted from Axe et al.²^bActive rest may include cardiovascular activity and short-game work from the service line to the net. Avoid overhead activity.

highest level of tennis competition. Coaches and HCPs should consider individualizing this program based on the needs of the athlete. The “unit dose” of 40 serves per set can be used to estimate the shoulder load and guide match planning.

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