

Improved General Health Outcomes in US Recreational Tennis Players

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ABSTRACT

Purpose:

The United States Tennis Association (USTA) is the largest competitive adult tennis league in the United States. Although there have been extensive studies employing the Short Form-36 (SF-36) outcomes survey on disease specific populations, there is a paucity of data available concerning athletes. This investigation aims to determine if tennis players score better than general population norms on the Short Form-36 outcomes survey.

Methods:

The present study is a cross-sectional study employing a modified SF-36 version 1.0, administered to USTA League members. The following patient variables were collected: age group, days of tennis per week, self-reported ability, National Tennis Rating Program (NTRP) score, smoking status, body mass index, and assigned gender at birth. Population norm-based SF-36 domains were calculated. Sub-analyses were performed for patients competing more than 4 days/week, elite tennis ability (NTRP > 4), and patients over 70 years old.

Results:

10,380 USTA league members were included for analysis. For all SF-36 domains, tennis players scored higher than the general population mean (general population mean=50). Athletes who reported playing tennis more times a week had higher SF-36 outcomes (all domains $p < 0.01$). Elite tennis players (NTRP > 4) scored higher on the SF-36 physical functioning domain than those with less advanced tennis skills. Athletes who reported playing more than 3 days per week scored higher in all categories than those who competed less frequently.

Conclusions:

In reference to the general population, USTA League athletes have higher general, physical, social and mental health scores. The present study indicates health benefits of tennis in athletes of all ages, ability and frequency.

Key Words:

SF-36, Patient Reported Outcomes, Tennis, Athletes



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INTRODUCTION

Tennis is one of the most popular recreational sports worldwide with international organizations in more than 200 countries and with more than 75 million participants worldwide.⁽¹⁾ In the United States, the US Tennis Association Leagues is the largest adult competitive tennis organization in the country. Tennis athletes make up a diverse population, varying in experience, skill and physical fitness.

The physical health benefits of exercise are well-established, including decreasing the risk of cardiovascular disease and diabetes, improving lipid profiles, and increasing bone density and strength.⁽¹⁻⁶⁾ Furthermore, the mental benefits of exercise, including improved cognitive performance and memory have also been noted.⁽²⁻⁷⁾ There is strong evidence to support the health-related quality of life benefits conferred to athletes in comparison to non-athletes.⁽⁸⁻¹¹⁾ A positive relationship of the beneficial effects of exercise (specifically running) has been seen with increasing duration and frequency.⁽²⁵⁾ However, the majority of athletes in these studies have focused primarily on elite groups in comparison to the general population.⁽⁸⁻¹¹⁾ Moreover, the influence of specific sports on health, however, has not been well studied.

The SF-36 is a validated and commonly used metric for evaluating various aspects of health that contribute to an individual's quality of life and overall health state. Although there has been extensive research characterizing the SF-36 in various medical conditions, there is a lack of information with regards to the general, physical, social and mental health of competitive adult athletes. Previous studies examining SF-36 scores in athletes have focused on the elite (collegiate) level across a variety of sports.^(1,8,9,19,15) There is little known about the benefits on general health of playing a specific sport, as measured by the SF-36.

The present study hypothesizes that even at a nonprofessional level, tennis players would have improved health-related quality of life scores than the general population with improvements related to increased frequency of play, higher skill level and lower BMI.

METHODS

A modified SF-36 version 1.0 was administered to USTA Leagues players via online survey form. Additionally, the following patient variables were included: age group (18-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+), days of tennis per

week (0, 1 2-3, 4-5, 6+), self-reported ability via National Tennis Rating Program (NTRP) score (2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5), smoking status, body mass index (BMI) and assigned gender at birth. NTRP scores are based on a rubric that breaks down player skills into forehand, backhand, serve/return of serve, volley, special shots and playing style.

The SF-36 outcomes survey generates standardized domains that characterize eight health concepts. The included domains in this investigation were physical functioning (PF), bodily pain (BP), role limitations due to physical health problems (role physical: RP), role limitations due to personal or emotional problems (role emotional: RE), general mental health (MH), social functioning (SF), energy/fatigue or vitality (VT), and general health perceptions (GH). Individual items that contribute to a scale are scored in such a way that higher scores correspond to a better health state and all items for a domain are averaged together. In order to normalize to the general population, Norm-Based Scores (NBS) were computed for these domains using an algorithm provided by Optum (General population mean = 50, SD = 10). Two summary scores were generated using the SF-36 data: the Physical Component Summary (PCS) score and the Mental Component Summary (MCS) score. These are both aggregate of the eight scale scores and confer several analytical and statistical advantages, including smaller confidence intervals and smaller ceiling/floor effects.⁽⁴⁾ The methodology of calculating the PCS and MCS scores has been previously published and validated by Taft *et al.*⁽¹⁴⁾ Norm-based scores were computed for all SF-36 domains which are population adjusted based on age and gender sub-stratifications of the original sample of the United States population that was used to create and validate the SF-36 version 1.0.

Sub-analyses were performed to evaluate the effect of more frequent play, higher self-reported skill level, older age, and higher BMI. USTA Leagues members who were competing more than 4 days/week were categorized to be more frequent players. The NTRP rating system defines an NTRP score of 4 as any player who demonstrates very consistent shots, using speed and spin effectively, with a high level of control for all different strokes, and adjusts strategy to opponents' style of play. The authors considered any player with an NTRP score greater than or equal to 4 as an elite player. Players over 70 years old were considered to be elderly athletes. BMI was categorized based on the World Health Organization's Definition of obesity: Normal weight (BMI: 15-25), Overweight (BMI: 25-30), and Obese (BMI: 30+).

Independent-samples t-tests were employed to compare continuous variables with normal distribution between

groups. Multivariate analysis was conducted using ANOVA. All statistical tests were conducted using Statistical Package for the Social Sciences (SPSS), Version 22.0. Statistical significance was set at $p < 0.05$. All results were compiled securely and confidentially with no risk to human or animal subjects. Appropriate IRB approval was obtained for this investigation.

RESULTS

Demographics and USTA Characteristics

Surveys were sent via email to 312,447 USTA Leagues members. There were 10,380 USTA League members who

responded and completed the modified SF-36 questionnaire. The majority of respondents were between the ages of 40 and 69 years (Table 1). Females comprised 63% of the athletes, the average BMI of the cohort was 24.8 \pm 4.1 kg.m⁻², and 1.4% of the cohort were smokers (Table 1). 97.7% of athletes reported that playing tennis helps manage their health. When tennis players were asked how often they played tennis, 1,048 (10.1%) reported one day/week, 6,329 (61%) responded with two to three days/week, 2,648 (25.5%) responded with four to five days/week, and 255 (2.5%) responded with six to seven days/week. 8,823 (85%) athletes competing at the 3.0-4.0 NTRP level.

Table 1. Demographics distribution and USTA rankings of respondents.

	No. of Respondents	%
Total Number	10,380	100%
Age Group		
18-29	308	3.0%
30-39	683	6.6%
40-49	2073	20.0%
50-59	3399	32.7%
60-69	2768	26.7%
70-79	990	9.5%
80-89	72	0.7%
Sex (F)	6575	63% Female
BMI	10096	24.88 \pm 4.173
Smoking Status (Y)	143	1.4%

	No. of Respondents	%
Days of Tennis Playing Per Week		
0	98	0.9%
1	1050	10.1%
2-3	6329	61.0%
4-5	2648	25.5%
6-7	255	2.5%
NRTP Score		
2.5	560	5.4%
3.0	2269	22.0%
3.5	3707	36.0%
4.0	2777	27.0%
4.5	855	8.32%
5.0	118	1.11%
5.5	5	0.49%

SF-36 Outcomes for USTA Leagues Members

For all norm-based SF-36 domains, USTA Leagues players scored higher than the general population mean (mean = 50, SD = 10) (Table 2). Multivariate comparisons between

age groupings revealed higher SF-36 outcomes scores for younger athletes (all SF-36 domains, $p < 0.01$). Athletes who reported playing tennis more times a week had higher SF-36 outcomes (all domains, $p < 0.01$) (Table 3).

Table 2. Descriptive Statistics for Norm-Based SF-36 scores. Mean for the general population is equivalent to a score of 50. SD=Standard Deviation

General Health Outcomes	Number of Respondents	USTA Respondents Mean (SD)	General Population Mean (SD)
Physical Functioning	10311	54.74 (4.76)	50.00 (10.0)
Role Physical	10301	53.94 (6.62)	50.00 (10.0)
Bodily Pain	10302	52.01 (7.36)	50.00 (10.0)
General Health	10324	55.62 (6.70)	50.00 (10.0)
Vitality	10290	56.39 (7.48)	50.00 (10.0)

General Health Outcomes	Number of Respondents	USTA Respondents Mean (SD)	General Population Mean (SD)
Social Functioning	10308	54.25 (5.99)	50.00 (10.0)
Role Emotional	10293	53.31 (6.47)	50.00 (10.0)
Mental Health	10289	53.36 (7.09)	50.00 (10.0)
Summary: Physical Component	10285	54.00 (5.85)	50.00 (10.0)
Summary: Mental Component	10287	54.34 (7.11)	50.00(10.0)

Table 3. Whole cohort multivariate ANOVA comparisons for Norm Based Scores (NBS) SF-36 Domains based on the number of days played week (top), and NTRP Rating (bottom). PF: physical functioning, RP: role physical, BP: bodily pain, GH: general health, VT: vitality, SF: social functioning, RE: role emotional, MH: mental health.

Days played per week	PF Mean (SD)	RP Mean (SD)	BP Mean (SD)	GH Mean (SD)	VT Mean (SD)	SF Mean (SD)	RE Mean (SD)	MH Mean (SD)
1 day	54.1 (5.8)	53.2 (7.4)	52.1 (8.1)	53.5 (7.2)	53.0 (8.7)	53.2 (6.9)	52.0 (8.3)	52.2 (8.0)
2-3 days	54.6 (4.6)	53.6 (6.9)	51.8 (7.2)	55.5 (6.6)	56.1 (7.5)	54.2 (6.0)	53.2 (6.4)	54.3 (7.0)
4-5 days	55.1 (4.4)	54.5 (5.7)	52.8 (7.0)	57.5 (6.0)	58.2 (6.7)	55.1 (4.6)	54.0 (5.1)	55.9 (6.0)
6-7 days	55.0 (3.1)	54.5 (5.1)	54.5 (6.2)	57.9 (5.2)	59.2 (6.8)	53.8 (8.1)	54.1 (4.1)	55.6 (7.4)
p value	<0.001	<0.001	0.014	<0.001	<0.001	<0.001	<0.001	<0.001
NTRP Rating								
2.5	55.1 (4.4)	54.4 (6.0)	52.5 (7.0)	55.7 (7.0)	55.5 (8.1)	54.1 (6.1)	53.2 (6.4)	53.5 (7.5)

NTRP Rating								
2.5	54.5 (5.1)	53.9 (6.6)	52.2 (7.4)	55.5 (6.9)	56.2 (7.4)	54.3 (5.8)	53.3 (6.4)	54.3 (6.9)
3.5	54.6 (4.6)	53.9 (6.7)	51.9 (7.4)	55.6 (6.7)	56.5 (7.5)	54.3 (6.0)	53.3 (6.5)	54.5 (7.2)
4.0	54.9 (4.6)	54.0 (6.5)	51.9 (7.3)	55.8 (6.6)	56.7 (7.4)	54.3 (6.0)	53.5 (6.2)	54.5 (7.1)
4.5	54.9 (5.2)	53.7 (7.1)	51.8 (7.6)	55.4 (6.5)	56.1 (7.6)	54.1 (6.3)	53.1 (7.2)	54.3 (7.0)
5.0	55.8 (4.1)	54.9 (5.1)	52.7 (7.2)	56.9 (5.9)	56.2 (6.9)	54.3 (6.4)	52.2 (8.1)	53.7 (6.4)
5.5	52.1 (10.1)	53.4 (6.3)	45.4 (13.8)	54.4 (10.3)	56.6 (8.6)	49.5 (17.0)	53.2 (4.7)	54.5 (12.9)
p value	0.001	0.274	0.085	0.290	0.240	0.624	0.299	0.108

The whole cohort was filtered for elite tennis athletes, as defined by a NTRP rating greater than 4 (N=3755) (Table 4). Even among elite tennis players, those who played more days per week had higher domain scores in 7 of 8 categories, with only bodily pain scores unimproved when more days were more played. These players scored higher for the SF-36 physical functioning domain than those with less advanced tennis skills (54.64±4.78 vs 54.93±4.71, p=0.003). Elite tennis players were also found to have lower mean BMI than less skilled tennis athletes. Additionally, USTA league members who reported playing more than 3 days per week scored higher in all SF-36 categories (PF: 54.56 vs 55.19, p<0.01, RP: 53.70, vs 54.55, p<0.01; BP: 51.88 vs 52.35, p<0.01, GH: 55.08 vs 57.01, p<0.01, VT: 55.80 vs 57.90, p<0.01; SF: 54.06 vs 54.74, p<0.01, RE: 53.13 vs 53.74, p<0.01; MH: 54.01 vs 55.27, p<0.01).

The SF-36 domains were compared between male and female athletes. This analysis revealed that female athletes had worse pain scores (higher SF-36 BP), accompanied by higher general health and physical component summary

scores (PCS), and lower BMI (BP: 51.49 vs 52.26, p<0.01; GH: 54.54 vs 56.63, p<0.01; PCS: 53.54 vs. 54.48, p<0.01; BMI: 26.11 vs 23.36 kg.m-2, p<0.01).

Elderly tennis players (age > 70 years) scored worse than younger competitors for physical function, role physical, general health, vitality, social functioning, role emotional, and mental health domains for the SF-36 (PF: 95.36 vs 92.47, p<0.01; RP: 92.63 vs 90.54, p<0.01; GH: 81.58 vs 82.97, p<0.01; VT: 68.17 vs. 74.41, p<0.01; SF: 92.52 vs 94.75, p<0.01; RE: 92.20 vs. 95.85, p<0.01; MH: 81.34 vs 85.49, p<0.01).

Table 5 illustrates the present study's data alongside previously published studies employing the SF-36 outcomes domains in both elite athletes and normative populations. Un-adjusted scores from the present study are listed alongside previously published data for elite, collegiate athletes.^(1,8) Norm-adjusted SF-36 scores are listed alongside previously published, normative data for the general population and for adolescent athletes.^(4,15)

Table 4. Among elite-level tennis players (NTRP 4+), SF-36 domains compared between different groups by days played per week. Statistical significance is set at p<0.01.

Days played per week	PF Mean (SD)	RP Mean (SD)	BP Mean (SD)	GH Mean (SD)	VT Mean (SD)	SF Mean (SD)	RE Mean (SD)	MH Mean (SD)
1 day	54.0 (6.7)	53.9 (6.6)	51.7 (8.9)	53.4 (6.5)	52.5 (8.4)	52.8 (7.5)	51.7 (9.0)	50.8 (8.8)
2-3 days	54.8 (4.9)	53.4 (7.2)	51.9 (7.4)	55.3 (6.5)	56.4 (7.4)	53.8 (6.3)	52.9 (7.0)	54.4 (6.9)
4-5 days	54.9 (5.0)	54.5 (5.5)	52.5 (6.8)	57.1 (5.7)	58.1 (6.2)	55.0 (4.8)	54.0 (4.8)	55.9 (5.3)
6-7 days	55.0 (3.1)	53.1 (6.8)	53.0 (7.4)	58.4 (5.2)	57.9 (6.7)	53.2 (7.3)	53.7 (3.9)	56.6 (5.3)
p value	0.009	0.001	0.150	<0.001	<0.001	0.002	0.008	<0.001

Table 5. SF-36 health domains from the present study and previously published population norms. Non-weighted SF-36 scores refer to un-adjusted, non-weighted scores. Norm-Based SF-36 scores are adjusted such that the general population mean is 50 (SD=10).^{8,15,19,13}

	McAllister et al (2001) ¹	Huffman et al (2008) ⁸	Snyder et al (2010) ¹⁵	Maglente et al (2011) ⁴		
Population	USTA Leagues Players	NCAA Division I Athletes	NCAA Division I and II Athletes	USTA Leagues Players	High School Athletes	US General Population
Scoring System	Un-weighted SF-36	Unweighted SF-36	Unweighted SF-36	Norm-Based SF-36	Norm-Based SF-36	Norm-Based SF-36
N	10,380	562	696	10,380	219	3,844

	Non-Weighted SF-36 Scores			Norm Based SF-36 Scores		
	Mean (SD)	Mean (SE)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Physical Component Summary	54.00 (4.85)	52 (0.4)	--	54.00 (5.85)	53.2 (5.4)	49.22 (15.13)
Mental Component Summary	54.34 (7.11)	52 (0.5)	--	54.34 (7.11)	49.6 (9.5)	53.78 (13.14)
Physical Function	94.27 (11.4)	95 (0.9)	97.7 (8.0)	54.74 (4.76)	55.1 (4.5)	50.68 (14.48)
Role Physical	91.86 (23.4)	87 (1.9)	94.5 (17.8)	53.94 (6.62)	52.2 (7.0)	49.47 (14.71)
Role Emotional	93.56 (20.5)	91 (1.6)	96.8 (14.2)	53.31 (6.47)	49.6 (9.4)	51.44 (13.12)
Bodily Pain	74.93 (17.2)	75 (1.5)	83.9 (17.9)	52.01 (7.36)	52.1 (8.3)	50.66 (16.28)
Mental Health	82.90 (12.5)	78 (0.9)	82.6 (10.7)	53.36 (7.09)	51.2 (9.4)	54.27 (13.28)
Vitality	70.50 (15.8)	67 (0.9)	69.1 (13.7)	56.39 (7.48)	51.8 (9.7)	53.71 (15.35)
Social Function	93.34 (13.8)	85 (1.4)	94.5 (11.9)	54.25 (5.99)	51.5 (8.1)	51.37 (13.93)
General Health	82.10 (14.3)	77 (1.1)	84.5 (13.4)	55.62 (6.70)	48.8 (5.4)	50.10 (16.87)

DISCUSSION:

The present study is the largest cross-sectional study to date to use Norm-Based SF-36 scores to characterize the health state of a sport specific population. There were 10,380 USTA League players encompassing a range of ages and abilities who were determined to have general, physical, social and mental health scores comparable to previous literature with elite collegiate athletes, and higher scores than studies characterizing the general population (Table 5). Furthermore, athletes who played more and were of a higher self-reported skill level were found to have even better outcomes.

One of the primary motivations for the present study was to determine the extent to which players associated their tennis activity with improvements in their health. When asked whether playing tennis helped them in managing their health, 97.7% of respondents replied affirmatively. This overwhelming majority confirms the positive impact that playing a sport at any level can have on a player's well-being, even in such a large, heterogenous sample of athletes. Additionally, only 1.3% of athletes reported smoking tobacco, which is lower than previously published evidence of smoking prevalence in the United States. (16-17) The low rate of tobacco smoking in this population may highlight an unanticipated positive externality of participating in recreational sports—that athletes more often avoid deleterious habits.

Another strength of our study was the ability to stratify athletes based on frequency of play and skill level. Tennis athletes who played more frequently (>3days/week) had higher SF-36 scores for all eight subscales. Additionally, players with higher skill levels had higher physical functioning scores and lower BMI than other tennis players of a lesser ability. Previously, McAllister *et al* demonstrated that higher frequency of play for collegiate athletes was correlated with higher SF-36 MCS and GH. ⁽¹⁾ Additionally, the present study reports that 10% of respondents compete past the age of 70. An investigation performed by Pluim *et al* suggested that tennis-injury incidence ranged from 0.04 to 3.0 injuries per 1000 hours played. ⁽¹⁰⁾ In this way, tennis has appeal as a lifelong sport and form of exercise that may confer a lower risk of injury complemented by more experience.

The present study has several limitations. Despite using a validated outcomes metric and distributing the survey in a user-friendly online submission form, the collection of data via survey inherently allows for nonresponse error, due to some recipients not completing and returning the survey. Moreover, there was some non-compliance in completing all items on the survey or withholding certain answers for reasons unknown to the investigators. Finally, the introduction of demographic items in the questionnaire may have also had an effect on the accurate completion of the SF-36 portion, despite the authors' ensuring confidentiality and anonymity. Nevertheless, our study is the largest of its kind to date to support the health benefits of tennis.

Future directions for research include the comparison of the health benefits of tennis to other sports as well as further investigation into the effects of different skill levels, frequency of play and demographic factors. In addition, the health benefits of tennis in managing chronic disease in an aging population should be further investigated.

CONCLUSION

USTA Leagues players have higher general, physical, social and mental health scores than the general population median as measured on the SF-36. Patients with a higher level of skill have higher physical functioning. Younger tennis players and athletes who competed more than three times per week scored higher in all SF-36 domains than those who were older and played less, respectively. The present study demonstrates the health benefits of tennis to players of all ages, skill levels and frequency in the largest cross-sectional study of its kind to date.

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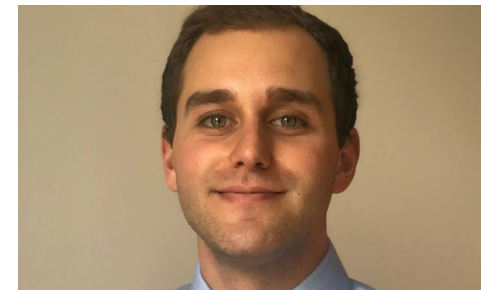
Dr. Alexis Colvin

is a board certified orthopedic surgeon and Associate Professor in the Department of Orthopaedic Surgery at Mount Sinai Hospital. The previous Chief Medical Officer of the USTA, she is the current CMO of the U.S. Open and the team physician for the U.S. Fed Cup team. She has also served as a physician at the United States Olympic Training Center in Colorado Springs, CO. She is also the co-editor of *The Young Tennis Player*.



Dr. James Gladstone

is Chief of the Sports Medicine Service and Associate Professor of Orthopedic Surgery at the Icahn School of Medicine at Mount Sinai. Dr. James Gladstone is the Medical Advisor to the US Men's Davis Cup tennis team and orthopedic consultant for the US Open tennis tournament and NFL Officials. He is currently involved in several clinical studies, one of which was an FDA Phase II study, where he was the principal investigator on a novel method of transplanting cartilage cells for chondral injuries in the knee joint.



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