Int J Physiol Pathophysiol Pharmacol 2021;13(2):36-42
www.ijppp.org /ISSN:1944-8171/IJPPP0120949

Original Article

A cross-sectional cadaveric study of the correlation between genital organ measurements, serum testosterone, and serum prostate-specific antigen levels in Japanese male subjects

Yuta Takeshima[1], Motofumi Suzuki[2,3], Hiroshi Ikegaya[4], Nozomi Idota[4], Taketo Kawai[2], Yusuke Sato[2], Haruki Kume[2]

[1]Division of Innovative Cancer Therapy, The Advanced Clinical Research Center, Institute of Medical Science, The University of Tokyo, 4-6-1 Shirokanedai, Minato-Ku, Tokyo 108-8639, Japan; [2]Department of Urology, Graduate School of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-Ku, Tokyo 113-8655, Japan; [3]Department of Urology, Tokyo Metropolitan Bokutoh Hospital, 4-23-15 Kotobashi, Sumida-ku, Tokyo 130-8575, Japan; [4]Department of Forensics Medicine, Kyoto Prefectural University of Medicine, Kajii-cho 465, Kawaramachi-Hirokoji, Kamigyo-ku, Kyoto 602-8566, Japan

Received August 23, 2020; Accepted November 19, 2020; Epub April 15, 2021; Published April 30, 2021

Abstract: Association of organ sizes in the genitalia have long been a topic of interest for the general public. However, factors such as selection bias, embarrassment, and invasive testing have hindered studies on living individuals. We obtained measurements of penile size, testicular weight, and prostate weight, and conducted related serum testing on 63 Japanese male adults who died of unexpected reasons and underwent autopsy from 2009 to 2013. Micropenis was seen in 7 subjects (11.1%) as determined by flaccid penile length. Penile measurements were mainly correlated with body weight, testicular weight with age and body mass index, and prostate weight with age and serum prostate-specific antigen level. No correlation was detected between testosterone and any genital organ measurements. Interestingly, penile circumference showed no correlation to any of the penile length measurements. Prostate weight showed a significant positive correlation with penile circumference, penile stretched length, and testicular weight. Although the direct clinical implications are unclear, utilizing autopsy provided insight into genital organ measurements free of patient selection bias and other disadvantages of live patient testing. With a larger sample size, autopsy studies may be of use to future adjustment of nomograms.

Keywords: Autopsy, penile length, testicular weight, prostate weight, testosterone

Introduction

Three organs particular to the male anatomy are frequently associated with "masculinity", the penis, the testes, and the prostate. Penile size has historically been symbolic of such attributes as strength, power, and fertility in many cultures dating back thousands of years [1]. The sizes of both the flaccid and erect states of their penis are an important issue to many men, and as many as 45% are reported to be unsatisfied [2]. Testicular size has also been linked to courage and fertility. Patients with cryptorchidism or who have undergone orchiectomy have been reported to harbor feelings of shame or loss [3, 4]. More recently, the prevalence of prostate cancer has led to surgical or hormonal therapies resulting in such symptoms as incontinence or impotence, affecting patients' sense of masculinity [5]. Studies from living and cadaveric subjects have shed light on the somatometry of these organs, establishing guidelines on which to base treatments such as penile augmentation or testicular prosthesis [6, 7].

Owing to the interest of the general population regarding the genitals, association between organ sizes have been a topic of 'myths' throughout history. However, the correlation between the sizes of these organs, especially concerning the prostate, have rarely been studied despite evidence that genital organ measurements correlate well with other factors such as hormonal levels and sperm production [8]. Here, we report an analysis on the correla-

Table 1. Demographics of subjects (n = 63)

age (years)	median (range)	65 (21-89)
height (cm)	mean ± SD	167.2 ± 7.5
weight (kg)	mean ± SD	61.4 ± 14.7
BMI (kg/m^2)	mean ± SD	21.8 ± 4.4
PFL (cm)	mean ± SD	7.6 ± 1.8
PSL (cm)	mean ± SD	11.2 ± 2.2
PSR (%)	median (IQ range)	43.8 (28.6-61.5)
PC (cm)	mean ± SD	8.1 ± 1.3
right testis (g)	mean ± SD	18.9 ± 6.0
left testis (g)	mean ± SD	18.5 ± 5.7
prostate weight (g)	median (IQ range)	30.5 (24.4-39.0)
serum TST (ng/mL)	median (IQ range)	3.2 (1.7-4.5)
serum PSA (ng/mL)	median (IQ range)	2.8 (1.3-11.0)

Abbreviations: BMI: Body Mass Index, PFL: Penile Flaccid Length; PSL: Penile Stretched Length, PC: Penile Circumference; PSR: Penile Stretched Rate, TST: testosterone, PSA: prostate-specific antigen.

tion between measurements of the penis, testes, and prostate, clinical parameters, and related serum testing. We conducted this initial study on male adult cadavers to account for selection bias, to obtain objective measurements in a homogenous environment, and to avoid the invasiveness of a transrectal ultrasound in a healthy cohort, especially in a setting where the clinical implication of the measurements are as yet unclear.

Methods

Subjects

From 2009 to 2013, Japanese males who underwent forensics autopsy at Kyoto Prefectural University of Medicine were enrolled. All subjects were fresh cadavers with intact external genitalia who died of unexpected reasons, and forensics autopsies were performed within 3 days of death. Subjects who underwent treatment for benign prostatic hyperplasia or prostate cancer were excluded from this study. Subjects under the age of 20 were also excluded as their genitalia may not have fully grown. The study was conducted under approval from the Institutional Review Board of Kyoto Prefectural University of Medicine (approval No. ERB-C-1491).

Pathological examination

Through a forensic examination, we removed organs including bilateral testes and prostate from the male corpses. Heart blood samples were collected and centrifuged. Obtained serum samples were immediately sent for laboratory examination at the LSI Medience Corporation (Tokyo, Japan). Serum testosterone (TST) (normal range, 1.92 to 8.84 ng/mL) and prostate-specific antigen (PSA) (normal range, 4.00 ng/mL or less) levels were measured by a chemiluminescent immunoassay method. To measure accurate weight of testes and prostate, we carefully removed adjunctive tissues (i.e., vas deferens, vessels, fatty tissue, and seminal vesicles) except for the epididymis. We measured penile size according to the method reported by Wessells et al [6]. Penile flaccid length (PFL) was determined with a ruler along the dorsum of the penis from the pubopenile junction to the tip of the glans. Penile stretched length (PSL) was measured under maximal extension of the phallus and penile circumference (PC) was measured at the mid-shaft of the penis. All measurements of penile size were performed in supine position under room temperature by the same examiner.

Statistical analysis

We defined penile stretched rate (PSR, %) by the following formula; [PSL-PFL]*100/PFL. Paired t-test was used to compare bilateral testicular weight. The mean testicular weight of left and right testes was used to study correlation with other parameters. We evaluated intergenerational differences of parameters by using a Turkey-Kramer honestly significant difference method. Correlation between clinical parameters, serum TST and PSA levels, and genital organ measurements were evaluated by using Spearman's rank correlation coefficients. Correlation among genital organ measurements were evaluated similarly with Spearman's rank correlation coefficients. Kruskal-Wallis test was used to compare mean testicular weight among groups categorized by body mass index (BMI). All statistical analyses were performed by using software (JMP Pro, version 14.2, SAS, Cary, NC), and *P* value less than 0.05 was considered significant.

Results

Demographics of study subjects are shown in **Table 1**. Total number of subjects was 63. There were seven subjects (11.1%) with PFL under 5.2 cm. This was the criteria presented

Table 2. Correlation between genital organ measurements, clinical parameters and serum testing

		age	body height	body weight	BMI	serum TST	serum PSA
PFL	correlation coefficient	0.198	-0.176	-0.396	-0.383	0.071	-0.044
	p value	0.118	0.165	0.001*	0.002*	0.578	0.827
PSL	correlation coefficient	-0.011	-0.032	-0.141	-0.157	0.076	0.047
	p value	0.931	0.804	0.271	0.218	0.555	0.815
PC	correlation coefficient	-0.16	0.224	0.279	0.241	0.164	0.059
	p value	0.21	0.078	0.027*	0.057	0.199	0.771
PSR	correlation coefficient	-0.17	0.125	0.284	0.265	-0.013	0.029
	p value	0.183	0.33	0.024*	0.036*	0.916	0.886
TW	correlation coefficient	-0.342	0.6	0.532	0.349	0.201	0.28
	p value	0.006*	<0.001*	<0.001*	0.005*	0.114	0.156
PW	correlation coefficient	0.274	0.159	0.247	0.217	0.027	0.408
	p value	0.03*	0.212	0.05	0.088	0.836	0.035*

*: statistically significant. Abbreviations: PFL: Penile Flaccid Length, PSL: Penile Stretched Length, PC: Penile Circumference, PSR: Penile Stretched Rate, TW: mean of left and right testicular weight, PW: prostate weight, BMI: Body Mass Index, TST: testosterone, PSA: prostate-specific antigen.

in the largest meta-analysis to date as the threshold of a micropenis as determined by PFL [9]. There were no subjects suffering from testicular diseases (e.g., testicular cancer, hydrocele, or epididymitis). The right testis was slightly heavier than the left, but no significant difference was seen ($P = 0.376$). Of 63 subjects, the right testis was heavier than the left in 33 (52.4%), the reverse in 26 (41.3%), and the same weight in 4 (6.3%) subjects. There were no statistical differences with regard to intergenerational differences between parameters except for body height (mean ± SD; 173.0 ± 5.2 cm in 40 s, 161.9 ± 5.0 cm in 80 s; $P = 0.011$) and right testicular weight (mean ± SD; 23.7 ± 7.3 g in 40 s, 15.6 ± 6.4 g in 80 s; $P = 0.043$).

Correlations between genital organ measurements and age, height, weight, BMI and serum tests are shown in **Table 2**. There was a significant negative correlation between PFL and body weight/BMI. Conversely, PSR was positively correlated to body weight and BMI. PC was positively correlated to body weight. PSL showed no correlation to any of the parameters. Testicular weight was negatively correlated with age, and positively correlated with body height, weight, and BMI. Prostate weight was positively correlated with age and serum PSA level. We could not observe significant correlation between serum testosterone levels and any of the organ measurements. The relation between penile measurements and postmortem time was analyzed, but Spearman's rank correlation coefficient was calculated as r = 0.131, showing very little correlation.

Correlations among genital organ measurements are shown in **Table 3**. PFL and PSL were positively correlated, as were PSL and PSR. PFL and PSR were negatively correlated, true to the definition of PSR. Interestingly, PC showed no correlation with any measurement of penile length. Prostate weight showed a significant positive correlation with PC, PSR, and testicular weight.

Discussion

The genitalia have long been a source of fascination and interest among the general public. In the clinic, and on the streets, we often receive questions and hear theories regarding the size of the genitals and their correlation to such parameters such as nose length, hand size, finger length, foot size, and the size of other genital organs. Despite this, there is a dearth of literature on the subject, perhaps owing to the embarrassment subjects experience when receiving a detailed examination of the genitals and the consequent difficulty in gathering a group of healthy subjects for analysis. To our knowledge, this is the first study to include measurement of the prostate in analysis of the correlation between genital organ measurements, and we found that prostate weight showed a significant correlation with PC, PSR, and testicular weight. It is also the first study to utilize testicular weight instead of testicular length as a measurement for size.

Table 3. Correlation among genital organ measurements

		PFL	PSL	PC	PSR	TW	PW
PFL	correlation coefficient	-	0.55	0.136	-0.584	0.019	-0.227
	p value	-	<0.001*	0.287	<0.001*	0.881	0.074
PSL	correlation coefficient		-	0.181	0.329	0.015	0.094
	p value		-	0.156	0.008*	0.906	0.462
PC	correlation coefficient			-	-0.0001	0.14	0.289
	p value			-	0.9997	0.273	0.022*
PSR	correlation coefficient				-	-0.048	0.29
	p value				-	0.711	0.021*
TW	correlation coefficient					-	0.321
	p value					-	0.01*

*: statistically significant. Abbreviations: PFL: Penile Flaccid Length, PSL: Penile Stretched Length, PC: Penile Circumference. PSR: Penile Stretched Rate, TW: testicular weight, PW: prostate weight.

Correlation between genital organ measurements and clinical parameters in past reports of living male subjects are inconsistent. We found a negative correlation between PFL and weight or BMI in our study subjects. Two previous studies found a similar negative correlation [10, 11], while two studies found positive correlations [12, 13], and one study found no correlation [14]. The same could be said for age or height, for which ours and similar studies [6, 14] did not find a significant correlation, but others did [10, 11, 13]. Correlation between organ measurements is not well documented. To our knowledge, there are only two studies which investigated the correlation between testicular size and either PFL or PSL, and none concerning prostate weight. Aslan et al. found a weak positive correlation for testicular volume and PFL/PSL [13]. Spyropoulos et al., in contrast, found a weak negative correlation [14]. Our study subjects did not exhibit a correlation between testicular weight and any of the penile measurements. Interestingly, prostate weight showed a significant positive correlation with testicular weight and PSR. With the high incidence of prostate cancer, a number of recent reports have focused on genital organ measurements, but the results shown here are the direct effects of surgery or hormone therapy [15, 16]. We targeted TST as a possible explanation for the correlation of genital organ sizes in a cohort without surgical intervention or hypogonadism. For all three genital organs in our study, a strong relationship with TST has been reported, for their differentiation during gestation, their development in puberty, and their homeostasis in adulthood [17, 18]. There were multiple reports in the literature exploring the correlation between testicular size and TST, reporting a weak to moderate positive correlation [8, 16]. We had hoped to find similar correlation between serum TST and genital organ measurements, but none were detected in our study subjects. Although our analysis of serum TST could not shed light on the bridge between the correlation of genital organ sizes and their clinical relevance, further insight into the interrelation of the male reproductive organs may hold clinical significance moving forward.

Our study design on cadavers offers several benefits when compared to a living patient cohort. The first benefit is the avoidance of patient selection bias, which has been mentioned in many studies of living subjects. There exists an element of embarrassment in the measurement of the genitals, leading to a presumed bias of volunteers taking part in studies because they were more confident in the size of their genitals than the general male population [9]. There are few descriptions of the selection process or the ratio of subjects who denied participation. There are also reports in which measurements were self-recorded by subjects, and significant bias may preclude comparison with other studies [19]. Postmortem time had little effect on PFL in our cohort, leading us to believe that postmortem PFL would be a reliable measure of that of living patients. Although a micropenis is defined as <2.5SD below the mean, or 0.14% of the population [20], we found a far larger number (7 subjects by PFL, 11.1%) fitting the criteria derived from the largest meta-analysis in the literature [9]. Three possible reasons for this deviation are the small sample size of this study, patient selection bias in the basis for

the criteria, and racial difference to previous studies. Cadaveric cohorts offer the benefit of eliminating selection bias and may be a better option on which to base penile length nomograms moving forward, providing a sufficient sample size may be gathered. Our subjects consisted entirely of East Asians, which may have affected the percentage of subjects diagnosed as a micropenis from a criterion derived from all races. Although some past reports suggested a smaller penile length and circumference in Mongoloids [21], no clear racial variability has been detected by meta-analysis at this point in time [9]. Future research of bias-free populations across races are needed to clarify this issue. The second benefit of the present study is that conducting the study on cadavers enabled us to attain higher consistency and objectivity in our measurements. Although most studies of penile length describe procedure of measurement, there is no single standard applied across all studies. The optimal force for PSL measurement and the inclusion of pubic fat pad depth are two factors which are inconsistent among studies [13, 22]. It has also been pointed out that factors such as temperature, level of arousal, and previous ejaculation could affect outcomes [9]. As patient factors such as arousal and pain tolerance during penile stretching were not an issue, we regarded our measurements to be of a homogenous standard not easily attainable in living subjects. The third benefit of the present study is that the use of cadavers allowed us to utilize testis and prostate weight as parameters. Regarding the prostate, difference in imaging method such as ultrasound or MRI [23], disagreement on optimal coefficient in estimating prostate volume [24], and individual error have indicated that prostate weight may be the preferred measure of prostate size as opposed to a (length × height × width × coefficient) equation [25]. Although data on testicular weight is scarce, similar observations have been made about testis volume that the standard coefficient for a standard ellipsoid model ($\pi/6 = 0.523$) underestimates true testis volume [26]. Also, vascular changes with age are known to play a role in testicular fibrosis, and using testis weight also accounts for these pathological changes [27]. Thus, we believe that using testis and prostate weight would give us a more objective look at the correlation between parameters. The fourth benefit of using cadavers was the avoidance of invasive or embarrassing testing on live subjects. As the clinical implications of this and similar studies of correlation between physical measurements are often unclear, we thought it pertinent to gain insight from cadaveric studies before potentially moving on to a living cohort.

Limitations for this study included small sample size, postmortem serum testing, and the use of PSL in place of erect penile length. Subjects were limited to those who died of unexpected reasons to further eliminate patient selection bias; thus, the analyzed cohort was considerably smaller than the total number of deaths. Patient selection will continue to be a hurdle for studies of the visible anatomy relying on healthy volunteers, and study designs that can gather a large cohort and also account for selection bias are needed. TST was targeted as a possible explanation of the correlations between genital organ measurements, but no correlation was detected in this study. We acknowledge that our negative data may have been brought about by postmortem serum testosterone levels being affected by factors such as postmortem interval, diurnal variation, and circumstance of death. A previous report measured serum TST levels postmortem in sudden infant death and reported that postmortem interval did not affect result, but we have no way of discerning how much these factors affected our own study [28]. Our use of cadavers obviously precluded us from measuring actual erect penile length. However, multiple reports show a strong correlation between erect penile length and PSL, and we feel that PSL is an adequate surrogate for erect penile length when limited to measuring correlation between parameters [6, 29].

While our study brought forth interesting results to consider in future studies, the direct clinical implication is unclear, as is often the case in studies of similar nature. We lacked information on reproductive potential including history of marriage, sexual activity, and number of children in our study. Future analysis of clinical backgrounds along with these metrics may shed light on the correlation between size of male genitalia and sexual health. There is certainly a need for larger cohort studies across various areas and ethnicities to develop better nomograms, but past studies have shown

us that patient selection bias is not an easy obstacle to eliminate concerning the genital organs. Autopsy studies of a larger scale may provide a solution to the various hurdles involved in obtaining objective genital organ measurements.

Acknowledgements

We thank Mr. Yoshihisa Akasaka for data collection and helpful discussion.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Hiroshi Ikegaya, Department of Forensics Medicine, Kyoto Prefectural University of Medicine, Kajii-cho 465, Kawaramachi-Hirokoji, Kamigyo-ku, Kyoto 602-8566, Japan. Tel: +81-75-251-5343; Fax: +81-75-251-5343; E-mail: ikegaya-tky@umin.ac.jp

References

[1] Wylie KR and Eardley I. Penile size and the 'small penis syndrome'. BJU Int 2007; 99: 1449-1455.

[2] Lever J, Frederick DA and Peplau LA. Does size matter? Men's and women's views on penis size across the lifespan. Psychology of Men and Masculinity 2006; 7: 129-143.

[3] Skoogh J, Steineck G, Cavallin-Ståhl E, Wilderäng U, Håkansson UK, Johansson B and Stierner U; SWENOTECA. Feelings of loss and uneasiness or shame after removal of a testicle by orchidectomy: a population-based long-term follow-up of testicular cancer survivors. Int J Androl 2011; 34: 183-192.

[4] Ku JH, Kim ME, Lee NK and Park YH. Testicular volume and masculine identity in men with unilateral cryptorchidism: results of a community-based survey in Korea. Urol Res 2003; 31: 312-316.

[5] Chapple A and Ziebland S. Prostate cancer: embodied experience and perceptions of masculinity. Sociol Health Illn 2002; 24: 820-841.

[6] Wessells H. Re: Dorsal free graft urethroplasty. J Urol 1996; 156: 1447.

[7] Tasaka T, Hiraga S, Kitamura M, Iida T, Kurokawa J, Hida M and Satoh T. First report on studies of normal testicular weight and size in the Japanese. Nihon Hinyokika Gakkai Zasshi 1986; 77: 1506-1510.

[8] Bahk JY, Jung JH, Jin LM and Min SK. Cut-off value of testes volume in young adults and correlation among testes volume, body mass index, hormonal level, and seminal profiles. Urology 2010; 75: 1318-1323.

[9] Veale D, Miles S, Bramley S, Muir G and Hodsoll J. Am I normal? A systematic review and construction of nomograms for flaccid and erect penis length and circumference in up to 15,521 men. BJU Int 2015; 115: 978-986.

[10] Promodu K, Shanmughadas KV, Bhat S and Nair KR. Penile length and circumference: an Indian study. Int J Impot Res 2007; 19: 558-563.

[11] Ponchietti R, Mondaini N, Bonafè M, Di Loro F, Biscioni S and Masieri L. Penile length and circumference: a study on 3,300 young Italian males. Eur Urol 2001; 39: 183-186.

[12] Mehraban D, Salehi M and Zayeri F. Penile size and somatometric parameters among Iranian normal adult men. Int J Impot Res 2007; 19: 303-309.

[13] Aslan Y, Atan A, Omur Aydın A, Nalçacıoğlu V, Tuncel A and Kadıoğlu A. Penile length and somatometric parameters: a study in healthy young Turkish men. Asian J Androl 2011; 13: 339-341.

[14] Spyropoulos E, Borousas D, Mavrikos S, Dellis A, Bourounis M and Athanasiadis S. Size of external genital organs and somatometric parameters among physically normal men younger than 40 years old. Urology 2002; 60: 485-489; discussion 490.

[15] Savoie M, Kim SS and Soloway MS. A prospective study measuring penile length in men treated with radical prostatectomy for prostate cancer. J Urol 2003; 169: 1462-1464.

[16] Haliloglu A, Baltaci S and Yaman O. Penile length changes in men treated with androgen suppression plus radiation therapy for local or locally advanced prostate cancer. J Urol 2007; 177: 128-130.

[17] Basaria S. Male hypogonadism. Lancet (London, England) 2014; 383: 1250-1263.

[18] Jarvis TR, Chughtai B and Kaplan SA. Testosterone and benign prostatic hyperplasia. Asian J Androl 2015; 17: 212-216.

[19] Herbenick D, Reece M, Schick V and Sanders SA. Erect penile length and circumference dimensions of 1,661 sexually active men in the United States. J Sex Med 2014; 11: 93-101.

[20] Aaronson IA. Micropenis: medical and surgical implications. J Urol 1994; 152: 4-14.

[21] Lynn R. Rushton's r-K life history theory of race differences in penis length and circumference examined in 113 populations. Personality and Individual Differences, 2013.

[22] Chen J, Gefen A, Greenstein A, Matzkin H and Elad D. Predicting penile size during erection. Int J Impot Res 2000; 12: 328-333.

[23] Murciano-Goroff YR, Wolfsberger LD, Parekh A, Fennessy FM, Tuncali K, Orio PF 3rd, Niedermayr TR, Suh WW, Devlin PM, Tempany CM, Sugar EH, O'Farrell DA, Steele G, O'Leary M, Buzurovic I, Damato AL, Cormack RA, Fedorov

AY and Nguyen PL. Variability in MRI vs. ultrasound measures of prostate volume and its impact on treatment recommendations for favorable-risk prostate cancer patients: a case series. Radiat Oncol 2014; 9: 200.

[24] Aprikian S, Luz M, Brimo F, Scarlata E, Hamel L, Cury FL, Tanguay S, Aprikian AG, Kassouf W and Chevalier S. Improving ultrasound-based prostate volume estimation. BMC Urol 2019; 19: 68.

[25] Hong MK, Yao HH, Rzetelski-West K, Namdarian B, Pedersen J, Peters JS, Hovens CM and Corcoran NM. Prostate weight is the preferred measure of prostate size in radical prostatectomy cohorts. BJU Int 2012; 109 Suppl 3: 57-63.

[26] Mbaeri TU, Orakwe JC, Nwofor AM, Oranusi KC and Mbonu OO. Accuracy of Prader orchidometer in measuring testicular volume. Niger J Clin Pract 2013; 16: 348-351.

[27] Gunes S, Hekim GN, Arslan MA and Asci R. Effects of aging on the male reproductive system. J Assist Reprod Genet 2016; 33: 441-454.

[28] Emery MJ, Krous HF, Nadeau-Manning JM, Marck BT and Matsumoto AM. Serum testosterone and estradiol in sudden infant death. J Pediatr 2005; 147: 586-591.

[29] Sengezer M, Oztürk S and Deveci M. Accurate method for determining functional penile length in Turkish young men. Ann Plast Surg 2002; 48: 381-385.