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ORIGINAL ARTICLE

Body Composition Differences in Army Paratroopers: Effect of Speciality, Age, and Gender

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Abstract: *Body composition has been associated with better performance in military populations. However, there is no consensus about the most suitable body composition values for army paratroopers. To analyze body composition differences among the type of specialty, age group, and gender of army paratroopers, for a better improvement of their operability. 104 paratroopers of the Spanish Army were analyzed. Anthropometric and morphological data were analysed throw an In-Body720. There was a significant effect of age on intracellular water. Older soldiers had lower values of intracellular water, protein, and skeletal muscle mass than middle-aged soldiers. No significant differences (P ≤ 0.05) for the effect of the kind of work and age together or taken separately. Men had significantly higher values than women for height, weight, extracellular water, protein, fat-free mass, and skeletal muscle mass, and significantly lower values for the percentage of body fat, while no differences were found for body fat mass and body mass index. We conclude that paratroopers' body composition depends on age in skeletal muscle mass, intracellular water, and protein. For better unit readiness, soldiers must be monitored to analyze the effect of training and nutrition habits on their body composition.*

Keywords: *military; body fat mass; lean mass; body water*

INTRODUCTION

Physical training is a key factor for soldiers, who are expected to perform efficiently in physical tasks and maneuvers, i.e. lifting and carrying weights, deployments, long displacements, or fighting [26]. Traditionally, Body Composition (BC) has been associated with better performance in military populations [13], like in load-carriage jobs, in which lean mass (together with aerobic power) has been identified as more important than speed of movement [21]. Despite these facts, there is still a tendency towards considering perceived assumptions, like appearance, rather than empirical data to evaluate the capabilities of each soldier, and weight plus Body Max Index (BMI) by themselves are not enough to assess military training since many other factors, like lean mass gain, are positive aspects of training that need to be measured [22,24].

Although some standards have been used and considered in the Army to encourage soldiers to keep fit and with good nutritional habits, there is no consensus about the most suitable BC for all the healthy ranges of weight, soft lean mass, or body fat percentage. This attempt becomes more complicated if we consider the wide range of duties required by the different units of the Army and the different soldiers´ ages [14,28]. The incorporation of women in the Army further complicates this issue, because there is a need to define gender-appropriate standards to maximize female soldiers' health and performance [14]. Taking sports, as a reference, different specializations would require different standards of body composition [2,37], like different jobs would require different BC in the Army, as it was reported for the Army [16,17,38] and Air Forces [4]. Moreover, BC is a variable that could be easily managed by any motivated soldier both with good fitness and nutrition habits, with the aim, not to predict the performance, but to obtain health benefits, resistance to disease or injuries [18,27], and better general capabilities, both mental and physical due to a balanced lifestyle [14,25].

Paratroopers are considered an elite unit of the Army since their deployments are highly operational and involve a parachute jump, which has been reported to increase heart rate and decrease fine motor skills [10,34]. Apart from the physical readiness required for a quick setup, prior to entering

the battlefield, they face additional hazards related to high altitudes, like hypoxia, disorientation, or night flights [3,5,6]. The principal tactical jumps are automatic para-chute jumps, in which the soldier has no control of the parachute opening, and manual parachute jumps, in which the subject has control of the parachute in all the maneuvers. Previous research found that both jumps produced a large stress response increasing cortisol, blood lactate, and sympathetic activation [8,10,11]. The health and performance of these kinds of units, which are under extreme psychological and physiological environments [7], can be undermined and there is a need to monitor their body composition [36], especially during their deployment in crisis management operations [29].

MATERIALS AND METHODS

Experimental approach to the problem

To implement the body composition assessment, we followed previous procedures [4,9,30] in which the participants stood upright on foot electrodes on the instrument platform, with arms not touching the torso. They were barefooted and without excess clothing. Four-foot electrodes were used, two of which were oval-shaped and two heel-shaped, and prior to testing the skin was cleaned and dried. Participants were asked to grip the palm and thumb electrodes. The system was calibrated before the testing session and the contacting surface of the electrodes was cleaned with alcohol before each measurement.

Participants abstained from alcohol consumption and vigorous exercise for 24h before the measurement and were measured in the morning after overnight fasting to control hydration status, as in previous research with bioelectrical impedance.

Subjects

A cross-sectional experimental design was conducted to analyze body composition differences of paratroopers, depending on their specialty, group age, and gender. 7 female paratroopers (specialty: automatic parachute; age: M = 32.1, SD = 8.79), and 97 male paratroopers were analyzed and classified into groups of specialty (43 automatic, age: M = 33.3, SD = 9.75; 54 manual, age: M = 34.8, SD = 7.58) and age (21 younger, under 29 years; 48 middle-aged, between 29 and 38 years; and 28 older, above 38 years) of the Spanish Army with a qualification of "fit" according to the periodic medical examination as recorded in the ministerial order 23/2011. Besides, during the research, they were carrying out the periodic aeromedical training included in the ministerial order 23/2011 and the STANAG 3114 "Aeromedical Training of Flight Personnel" (NATO regulations). Before starting the research, the experimental procedures were explained to all the participants, who gave their voluntary written informed consent under the Declaration of Helsinki. The procedures conducted in the present research were designed and approved by the Medical Service of the Aerospace Medicine Instruction Centre of Spanish Air Forces and the University Ethic Committee (CIPI/18/093).

Instruments

A bioimpedance analyzer (InBody 720, Biospace Co. Ltd., Seoul, South Korea) was used for body mass measurement (to the nearest 0.1 kg) and body height (to the nearest 0.1 cm). InBody 720 is a multifrequency impedance body composition analyzer, which uses an eight-point tactile electrode method to take readings from the body. It measures the resistance at five specific frequencies (1 kHz, 50 kHz, 250 kHz, 500 kHz, and 1 MHz) and reactance at three specific frequencies (5 kHz, 50 kHz, and 250 kHz) on each of five segments (right arm, left arm, trunk, right leg, and left leg). Bioelectrical-impedance analysis (BIA) is one of the methods available for measuring body composition in healthy populations. Its simplicity, portability, cost, and subject acceptance make it a very desirable technique. The reliability of BIA compared to the gold standard body composition measurement (DXA) has been successfully demonstrated for a wide range of normal and overweight populations [15,35] and military samples [1].

Data were electronically imported to Excel using Lookin'Body 3.0 software. The following parameters were analyzed: i. Body mass (kg), ii. Height (cm), iii. Body Mass Index (BMI) (kg/m^2), iv. Total Body Water (TBW) (kg) (including left and right arms, trunk, and left and right legs), v. Intracellular Water (ICW) (l) (including left and right arms, trunk, and left and right legs), vi. Extracellular Water (ECW) (l) (including left and right arms, trunk, and left and right legs), vii. Proteins (kg), viii. Minerals (kg), ix. Body Fat Mass (BFM) (kg) (including left and right arms, trunk, and left and right legs, in kg and %), x. Percentage of Body Fat (PBF) (%), xi. Soft Lean Mass (SLM) (kg), xii. Fat-Free Mass (FFM) (kg) (including left and right arms, trunk, and left and right legs, in kg and %), xiii. Skeletal Muscle Mass (kg).

Statistical analysis

The SPSS statistical package (version 21.0; SPSS, Inc. Chicago, Illinois) was used to analyze the data. Normality assumptions were checked with a Shapiro-Wilk test for all the subgroups and a Kolmogorov-Smirnov test for the whole group. Gender differences were analyzed for the same specialty (automatic parachute) with a T-Student test for parametric samples and a Mann-Whitney test for no parametric samples. Homoscedasticity was tested with the Levene test. A factorial ANOVA test was used to compare the type of work, the group of age, and the interaction between the type of work and the group of age on each parameter together with a Bonferroni post hoc test to analyze pairwise comparisons. The level of

significance for all the comparisons was set at P ≤ 0.05.

RESULTS

The results are reported with their mean and standard deviation. Table 1 shows the results of body composition. No significant differences were found for the effect of type of work and age together, but there was a significant effect of age [F(2, 91)=3.172, p = 0.047, η2 = 0.06], in ICW. Older soldiers (M = 28.3, SD = 2.8) had lower values (p = 0.041) of ICW than middle-aged (M = 30.3, SD = 3.7). There was a significant effect of age [F(2, 91)=3.108, p = 0.049, η2 = 0.06], in protein. Older soldiers (M = 12.2, SD = 1.2) had lower values (p = 0.043) of protein than middle-aged (M = 13.0, SD = 1.6). There was a significant effect of age [F(2, 91)=3.154, p = 0.047, η2 = 0.07], in SMM. Older soldiers (M = 34.9, SD = 3.6) had lower values (p = 0.041) of SMM than middle-aged (M = 37.5, SD = 4.9).

Table 1: Results of body composition variables by specialty and age groups

	Age < 28				28 < Age < 38				Age > 38				Age and specialty effect		
	Automatic		Manual		Automatic		Manual		Automatic		Manual				
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F	p	η^2
Height (cm)	178.8	7.5	177.5	7.0	177.3	6.2	175.2	5.9	174.3	5.8	175.0	5.7	0.47	0.66	0.01
Body Mass (kg)	75.3	7.1	79.4	14.1	83.4	15.4	78.9	10.6	73.6	9.4	76.5	9.2	1.40	0.25	0.03
BMI (kg/m^2)	23.6	2.6	25.1	3.6	26.3	3.5	25.6	2.8	24.2	3.0	24.9	2.6	1.03	0.35	0.02
TBW (l)	46.4	3.1	47.6	5.5	49.0	7.8	47.5	4.8	45.5	4.5	45.3	4.4	0.47	0.62	0.01
ICW (l)	29.1	1.9	29.9	3.6	30.7	4.9	30.0	3.0	28.4	2.9	28.3	2.8	0.36	0.69	0.01
ECW (l)	17.2	1.2	17.7	2.0	18.3	2.9	17.5	1.8	17.0	1.5	17.0	1.6	0.72	0.48	0.02
Proteins (kg)	12.6	0.8	12.9	1.5	13.2	2.1	12.9	1.3	12.2	1.2	12.2	1.2	0.33	0.71	0.00
Minerals (kg)	4.2	0.4	4.5	0.7	4.7	0.8	4.4	0.5	4.3	0.4	4.2	0.5	1.17	0.31	0.03
BFM (kg)	11.9	4.1	14.3	10.1	16.3	7.4	13.9	6.4	11.5	6.5	14.6	5.1	1.86	0.16	0.04
PBF (%)	15.6	4.4	16.9	9.1	19.0	6.3	17.1	5.7	15.1	6.8	18.8	5.3	1.83	0.17	0.04
SLM (kg)	59.8	4.0	61.3	7.2	63.2	10.0	61.3	6.2	58.5	5.8	58.3	5.6	0.45	0.64	0.01
FFM (kg)	63.3	4.3	65.1	7.7	67.0	10.8	64.9	6.6	62.1	6.1	61.8	6.0	0.48	0.61	0.01
SMM (kg)	36.0	2.5	37.1	4.7	38.1	6.4	37.1	3.9	35.0	3.8	34.9	3.6	0.38	0.68	0.01

Note. M = Mean; SD = Standard Deviation; F = Fisher-Snedecor test; η2 = Partial eta squared; BMI = Body Mass Index; TBW = Total Body Water; ICW = Intracellular Water; ECW = Extracellular Water; BFM = Body Fat Mass; PBF = Percentage of Body Fat; SLM = Soft Lean Mass; FFM = Fat Free Mass; SMM = Skeletal Muscle Mass

Table 2 shows the results of FFM and BFM by body segments. No significant differences were found for the effect of kind of work and age together or taken separately.

Table 2: Results of Fat-Free Mass and Body Fat Mass by body segments

	Age < 28				28 < Age < 38				Age > 38				Age and specialty effect		
	Automatic		Manual		Automatic		Manual		Automatic		Manual				
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F	p	η2
FFM Right Arm (kg)	3.65	0.31	3.76	0.52	3.93	0.76	3.79	0.49	3.56	0.55	3.58	0.47	0.39	0.67	0.01
FFM Left Arm (kg)	3.61	0.30	3.72	0.54	3.89	0.78	3.78	0.51	3.50	0.59	3.78	0.51	0.34	0.71	0.01
FFM Trunk (kg)	28.1	1.79	28.7	3.20	29.6	4.44	28.9	2.93	27.2	3.43	27.6	2.88	0.39	0.67	0.01
FFM Right Leg (kg)	10.0	1.01	9.94	1.09	10.1	1.49	9.71	1.02	9.32	0.91	9.37	1.00	0.42	0.65	0.01
FFM Left Leg (kg)	9.92	1.02	9.89	1.13	10.0	1.52	9.64	1.02	9.32	0.80	9.32	0.97	0.37	0.69	0.01
BFM Right Arm (kg)	0.52	0.26	0.75	0.86	0.86	0.56	0.68	0.56	0.55	0.51	0.75	0.35	1.67	0.19	0.04
BFM Left Arm (kg)	0.55	0.28	0.78	0.90	0.90	0.58	0.67	0.56	0.55	0.49	0.76	0.36	1.97	0.14	0.04
BFM Trunk (kg)	6.16	2.59	7.45	5.70	8.80	4.34	7.36	3.74	5.83	3.81	7.78	3.16	1.93	0.15	0.04
BFM Right Leg (kg)	1.82	0.47	2.07	1.22	2.30	0.90	1.98	0.77	1.74	0.82	2.10	0.57	1.87	0.16	0.04
BFM Left Leg (kg)	1.79	0.46	2.02	1.25	2.27	0.89	1.98	0.76	1.74	0.82	2.08	0.59	1.60	0.20	0.03

Note. M = Mean; SD = Standard Deviation; F = Fisher-Snedecor test; η2 = Partial eta squared; FFM = Fat-Free Mass; BFM = Body Fat Mass

Table 3 shows the results of body water (total, intracellular, and extracellular) by body segments. No significant differences were found for the effect of type of work and age together, but there was a significant effect of age [F(2, 91)=3.314, p = 0.041, η2 = 0.06], in the ICW of the trunk. Older soldiers (M = 13.3, SD = 1.51) had lower values (p = 0.035) in the ICW of the trunk than middle-aged (M = 14.2, SD = 1.71). Men had significant higher values than women for height (p=0.000; M = 176.9, SD = 6.6 vs M = 164.1, SD = 5.9), weight (p=0.000; M = 78.0, SD = 12.2 vs M = 60.0, SD = 6.8), TBW (M = 47.2, SD = 5.8 vs M = 34.0, SD = 2.1), ECW (p=0.000; M = 17.6, SD = 2.1 vs M = 12.8, SD = 0.73), ICW (p=0.000; M = 29.5, SD = 3.6 vs M = 21.2, SD = 1.3), Protein (p=0.000; M = 12.7, SD = 1.5 vs M = 9.2, SD = 0.6), Minerals (p=0.000; M = 4.4, SD = 0.62 vs M = 3.27, SD = 0.27), FFM (p=0.000; M = 64.4, SD = 8.0 vs M = 46.5, SD = 2.96), SLM (p=0.000; M = 60.7, SD = 7.5 vs M = 43.8, SD = 2.76), SMM (p=0.000; M = 36.5, SD = 4.8 vs M = 25.7, SD = 1.83), and significant lower values for PBF (p=0.034; M = 16.8, SD = 6.0 vs M = 22.0, SD = 4.3). No significant differences were found for the effect of gender between men and women in BFM (p=0.955; M = 13.5, SD = 6.5 vs M = 13.4, SD = 4.3) and BMI (p=0.065; M = 24.8, SD = 3.29 vs M = 22.34, SD = 2.9).

Table 3: Results of Body Water by Body Segments

	Age < 28				28 < Age < 38				Age > 38				Age and specialty effect		
	Automatic		Manual		Automatic		Manual		Automatic		Manual				
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F	p	η^2
TBW Right Arm (l)	2.84	0.23	2.92	0.40	3.05	0.59	2.94	0.38	2.77	0.42	2.78	0.37	0.39	0.67	0.01
TBW Left Arm (l)	2.80	0.23	2.89	0.42	3.02	0.61	2.93	0.40	2.72	0.46	2.77	0.38	0.37	0.69	0.01
TBW Trunk (l)	21.8	1.42	22.3	2.46	23.0	3.45	22.4	2.28	21.1	2.66	21.4	2.20	0.44	0.64	0.01
TBW Right Leg (l)	7.78	0.80	7.71	0.85	7.86	1.15	7.52	0.79	7.23	0.70	7.28	0.77	0.47	0.62	0.01
TBW Left Leg (l)	7.71	0.80	7.68	0.89	7.81	1.18	7.48	0.80	7.24	0.62	7.25	0.76	0.39	0.67	0.01
ICW Right Arm (l)	1.77	0.14	1.83	0.25	1.91	0.36	1.84	0.23	1.73	0.27	1.73	0.23	0.37	0.68	0.01
ICW Left Arm (l)	1.75	0.14	1.81	0.26	1.89	0.37	1.84	0.24	1.70	0.29	1.73	0.24	0.31	0.72	0.01
ICW Trunk (l)	13.7	0.85	14.0	1.60	14.4	2.17	14.1	1.43	13.2	1.71	13.3	1.40	0.32	0.72	0.01
ICW Right Leg (l)	4.90	0.47	4.88	0.53	4.95	0.73	4.77	0.49	4.55	0.46	4.55	0.49	0.29	0.74	0.01
ICW Left Leg (l)	4.83	0.48	4.82	0.54	4.90	0.74	4.72	0.49	4.53	0.39	4.52	0.47	0.27	0.76	0.01
ECW Right Arm (l)	1.06	0.09	1.08	0.14	1.14	0.22	1.09	1.14	1.04	0.15	1.04	0.14	0.43	0.64	0.01
ECW Left Arm (l)	1.05	0.09	1.08	0.15	1.13	0.23	1.09	1.15	1.02	0.16	1.04	0.14	0.47	0.62	0.01
ECW Trunk (l)	8.15	0.59	8.28	0.88	8.61	1.29	8.27	0.85	7.95	0.95	8.07	0.81	0.68	0.50	0.02
ECW Right Leg (l)	2.88	0.32	2.83	0.33	2.91	0.43	2.74	0.30	2.68	0.24	2.72	0.28	0.86	0.42	0.02
ECW Left Leg (l)	2.87	0.33	2.85	0.35	2.91	0.45	2.75	0.31	2.17	0.22	2.72	0.29	0.63	0.53	0.01

Note. M = Mean; SD = Standard Deviation; F = Fisher-Snedecor test; η2 = Partial eta squared; TBW = Total Body Water; ICW = Intracellular Water; ECW = Extracellular Water

DISCUSSION

This study aimed to analyze body composition differences between the type of specialty, age group, and gender of paratroopers.

The first hypothesis was fulfilled since there were no differences in body composition between specialties. The second hypothesis was partially fulfilled since there were differences in intracellular water, protein, and skeletal muscle mass between middle-aged and older soldiers. The third hypothesis was not fulfilled since there were no significant differences in body composition between male and female paratroopers.

The main parachute jumps conducted by paratroopers' units are automatic or manual. The characteristics of both jumps are different since in automatic parachute jumps there is a lack of parachute control during the flight and especially during the landing (with high impacts that directly affect the muscle and bone structures of jumpers).

On the contrary, in manual jumps the flight and landing phases allow for greater control by the jumpers, leading to a less traumatic landing. But independently of these differences, we did not find differences between jump specialties, a fact probably due to the similar training, instruction, and nutritional regimen of both groups. The only difference was the tactical maneuvers after both jumps, but the rest of the preparation and military context were similar in both groups.

Differences between ages were found in intracellular water, protein, and skeletal muscle mass. The middle-aged group had a better mean than the older group in all those variables. Since

the skeletal muscle is mainly built upon protein and water, these results show a tendency towards skeletal muscle loss with age.

The differences found could be related to the fact that middle-aged soldiers have complete growth, they are in their most operational phase in the unit, where they perform a higher number of jumps and the training is more intense, facts that could explain the higher intracellular water, protein, and skeletal muscle mass. This fact would join, with the investigations that support that resistance training promotes an increase in body water, principally by intracellular content [32]. On the other hand, older and younger participants perform a lower number of jumps: older paratroopers begin with the natural muscle mass loss process associated with age [33] and the younger paratroopers have not yet reached their growth zenith and their training in the unit is not yet maximum.

It is important to note that body fat mass, percentage of body fat, and soft lean mass, which have been usually reported as crucial for the performance of the units [13,21] were not different between groups, supporting the idea of the adequate habits of these troops during their service. Also, data analysis for body segments, reinforces the idea of the correct BC maintenance of these units, throughout their military service, despite their age, since no significant differences were found between groups of work and age.

Besides, if we compare the values of body mass index (24.12 kg/m^2 vs 25.88 kg/m^2 for age <28, 25.89 kg/m^2 vs 26.94 kg/m^2 for age between 28 and 38, and 24.64 kg/m^2 vs 26.86 kg/m^2 for age > 38); and body fat percentage (16.0% vs 16.6% for age < 28, 17.8% vs 18.8% for age between 28 and 38, and 17.2% vs 19.7% for age > 38) with some US Army standards, they are better for all the age groups [20]. Nevertheless, we should bear in mind that these groups are considered “elite” inside the Spanish army, and we are comparing them with a combination of soldiers from the combat support, combat arms, and combat service support units. However, results of body mass index and body fat percentage were higher than those reported for soldiers after 6 months of deployment in a crisis management operation (25.89 kg/m^2 vs 24.50 kg/m^2 and 17.8% vs 13.7%), a fact that highlights the need to monitor body composition during field activities, and especially on those with higher length, intensity or more stressful type [36]. Not only fat mass but fat-free mass and protein could be undermined during operational training or deployment [23,24].

If we compare these results with other Army units, body mass index and percentage of body fat are quite similar to airplane and helicopter pilots, but lower to other aircrew support members (25.49 kg/m^2 and 23.79% respectively) [4]. If we take body segments, there is a tendency towards having more fat-free mass in the right arm, which is consistent with previous research in the Air Forces [4], light forces [12], and even in females [39], which could be due to the prominence of right-handedness.

Regarding our third hypothesis about differences in BC according to sex, most of the BC male parameters in absolute terms were higher, while BFM and BMI did not show significant differences. Further investigation is recommended on this issue since the female sample size does not allow the values to be extrapolated and generalized.

Finally, regarding body water composition, there are no significant differences between age groups and manual or automatic parachute jumps in any of the variables analyzed, total, intracellular, and extracellular water. These values suggest an optimal balance of hydration among the healthy population and are correlated with a lower and healthier BMI [19], consequent with the normal-weight distribution among age and type of jump. Indeed, similar values of intracellular and extracellular values have been found in professional athletes depending on their composition whether it is an athlete or not [31].

The main limitation of this study was the small sample size of women. Secondly, we did not have permission to gather other demographic data (like nutrition, economic, education, and physical activity levels in leisure time) that could have helped us to better understand the differences between groups. These background variables could be studied further to design longitudinal research to understand the mechanisms of BC changes.

CONCLUSIONS

Paratroopers' Body Composition is not affected by their type of parachute specialty (automatic or manual) but depends on age for skeletal muscle mass, intracellular water, and protein. Older soldiers had lower values of ICW than middle-aged. Older soldiers had lower values of protein than middle-aged. Older soldiers had lower values of SMM than middle-aged. This data suggests good nutrition and training habits among the paratroopers. When comparing these data with previous research, it suggests that the body fat percentage of paratroopers is similar to airplane pilots, lower than aircrew personnel and combat and service soldiers, but higher than soldiers deployed. Body composition should be monitored to analyze the effect of training and nutrition habits during service, especially during stressful deployments. These facts must be considered to better prepare each unit.

Conflicts of interest and sources of funding

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Authors' contribution

Conceptualization, V.J.C.S. and A.B.S.; methodology, V.J.C.S. and A.B.S.; formal analysis, V.J.C.S. and A.B.S.; investigation, V.J.C.S. and A.B.S..; resources, V.J.C.S. and A.B.S.; data curation, A.B.S.; writing—original draft preparation, A.B.S.; writing—review and editing, V.J.C.S. and A.B.S..; supervision, V.J.C.S.; project administration, V.J.C.S.. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of UNIVERSIDAD EUROPEA DE MADRID (protocol code CIPI/18/093).

Patient consent for publication

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

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