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ORIGINAL ARTICLE

Auxotonic training in muscle strength and power performance of professional young volleyball players

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ABSTRACT

Auxotonic training unexplained on isotonic and isometric muscular contraction combination to develop strength and power gain. The study aimed to investigate muscle strength and power changes of professional young volleyball players on the auxotonic training effect. Volleyball players divided in AUT (auxotonic group: 16.32 y, 1.72 m, 63.63 kg) trained over 8 week and per week 2 day performing isotonic + isometric contraction combination periodization and IKT (isokinetic group: 16.23 y, 1.69 m, 60.22 kg) performed only isokinetic contraction periodization. The linear muscle strength and power processes of training periodization preferred for maximize performance. The strength changes of this study resulted on AUT and IKT for 1RM strength test and activforce isometric muscular strength adaptation test were similar, however, AUT obtained high improvement power performance ($p < .05$). Auxotonic training developed on strength and power for AUT. Additionally, showing of comparison between AUT and IKT concluded CMJ (90°) ES = 1.09 very large, vertical jump ES = 1.31 very large and handgrip right ES = 0.05 small effect size. Based on the results we obtained, current auxotonic contraction was determined on resistance training applied to young volleyball players effective in strength and power development. Auxotonic training performed on young volleyball players will bring a perspective to the coaches and athletes work in this field as a resistance training model. The auxotonic training strategy for long term performance changes on outcomes of using aimed potential muscle isotonic + isometric contraction combination may be effective maximize strength and power performance.

Keywords: Technology sport, Innovation sport, Auxotonic training, Strength, Power, Volleyball players.

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INTRODUCTION

Auxotonic resistance is one of training performance condition for upper and lower compartment maximal strength development obtained from muscular strain changes (Azeem et al., 2022). Auxotonic muscular performance of large muscle groups are combinate isotonic and isometric muscle action (Lee et al., 2018). Furthermore, isotonic muscular contraction preferred for push and speed phases of dynamic performance, other isometric muscular contraction to maximum strength and range of motion of static performance (Lee et al., 2018; Lum et al., 2023). In this case, isotonic and isometric actions detected to strength development and muscular force action (Azeem et al., 2022). Over the last study reported that 1RM-70% - 10 rep auxotonic resistance and 10 s isotonic moderate intensity training to leg performance are similar strength and power gain on acute changes (Lina-Samaniego et al., 2022). Periodic long term isotonic and isometric muscular resistance training showed that isotonic action increased in bench press 34.45%, sit-up 24.13% and flexibility 29.12% than isometric action in bench press 14.23%, sit-up 7.80% and flexibility 6.92% (Azeem et al., 2022). In resistance trained men, isotonic and isometric back squat mechanics performed on 1RM-75%, both isometric contraction (2.8%) and isotonic contraction (2.6%) developed vertical jump performance (Vargas-Molina et al., 2021). In this condition, isotonic and isometric combination limited to auxotonic training level in muscular strength and power performance on sport modalities (Lum et al., 2023). Specifically, isometric activation is common preferred for maximum strength in auxotonic training rapid force period (Lee et al., 2018; Lum et al., 2023; Comfort et al., 2022). Rapid strength transition was unexplained for isotonic + isometric contraction relationship on range of motion and speed mechanism (Lum et al., 2023; Comfort et al., 2022). In this case, early and late time-dependent resistance phases are explained on "*S = (Newton x time)*" is strength potential represented to late period 5 s and early period 1 s (Guppy et al., 2022). Isometric potential forces based on intensity of muscular contraction and proper muscle-tendon activation to range of motion increases high strength effort (Comfort et al., 2022). Indeed, auxotonic resistance is one of internal and external strength working on strain changes through strength development that isotonic + isometric actions are effective for strength loss and muscular activations (Lee et al., 2018). Different types of muscle contraction are performed on muscle strength and power development, however, auxotonic muscle strength should be known as the performance of shortening and range of motion in combined contractions (Lee et al., 2018). Why it is preferred is an important issue, because isotonic and isometric resistance training does not require special equipment, and performing exercises in very short intervals within certain ranges of motion of joints and muscles does not cause fatigue (Azeem et al., 2022; Lum et al., 2023). In this context, as isotonic and isometric strength changes increase after auxotonic training, it is necessary to conduct further research on the branch-specific use of such resistance training methods. To determine individual isotonic + isometric output used dynamic and static strength (Karagiannopoulos et al., 2022). However, maximal strength and power development strategies of auxotonic training needed for 1RM and vertical jump studies (Azeem et al., 2022). Therefore, this study aimed to auxotonic resistance training investigate on strength and power performance of professional young volleyball players.

METHOD AND MATERIALS

Participants

The study formed professional 26 female young volleyball players; AUT group (n = 13) age 16.32 ± 0.60 y, height 1.72 ± 0.05 m, weight 63.63 ± 7.74 kg isotonic + isometric training performed over 8 week and per week 2 day periodization. IKT group (n = 13) age 16.23 ± 0.59 y, height 1.69 ± 0.04 m, weight 60.22 ± 4.64 kg trained only isotonic muscular action periodization no participated isometric contraction session. Ethic permission acceded by Akdeniz University Clinic Committee Protocol-890/220/2021.

Procedure

1RM (one repetition maximum) test

One repetition maximum test using report of NSCA editors performed on participants. Initially performance condition determined on 10 min standard dynamic and static warm-up. Participants for upper compartment resistance exercises on 90-100% 1RM reach by increasing 4-9+ kg tested, again 1RM test incremental at 50% (5-10 rep), 80% (3-5 rep), 90% and 100% used for each test by smith machine (ProWellness Silver Line, LX serial, TR) and free-weight and dumbbell (Diesel series). Auxotonic resistance training exercises performed on a) wrist dorsal flexion using 5 kg dumbbell, b) wrist extension using 5 kg dumbbell, c) wrist abduction using 5 kg dumbbell, d) wrist adduction using 5 kg dumbbell, e) trunk lateral flexion using 5 kg dumbbell by 2.5 kg increase, f) upper rowing using upper row machine with increasing 3-4 kg, g) triceps press down using triceps push down machine by 5 kg increase, h) hip flexion using cable rowing by opposite U smith machine, ı) hip extension using cable rowing on opposite U machine, j) ankle dorsal flexion using smith machine with increasing 7 kg, k) ankle plantar flexion using cable row machine by 5 kg increase, l) ankle inversion using cable row machine with increasing 3-4 kg, m) ankle eversion using cable row machine by 3-4 kg increase, n) biceps curl using seated barbell machine with increasing 2.5-5 kg, o) shoulder pull down using shoulder machine by 3-4 kg increase, p) chest press using chest machine with increasing 5 kg, r) hip abduction using cable row machine by 5 kg increase, s) hip adduction using cable row machine with increasing 5 kg, t) leg curl using leg curl machine by 5 kg increase, u) leg extension using leg extension machine with increasing 5 kg, v) abdominal hyperextension using free-weight on sit-up machine by 5-10 kg increase, w) trunk flexion using weight with increasing 5-10 kg, x) trunk extension using weight by 5-10 kg increase, y) trunk rotation using weight with increasing 5-10 kg. Proper stabile protocol showed on each measurement and supporting image and verbal.

Activforce isometric muscle activation

Rapid strength potential isometric force-time curve performance performed on peak and average force. Totally isometric strength test performed on individual 20 min performance. To muscle activation evaluate "*Activforce 2 hand dynamometer*" (Activforce 2, Australia) used for reliable measurement (ICC = 0.85-0.99) (Karagiannoupolos et al., 2022). Upper and lower compartment extremity measurements analysed total 24 movement related nearest joint proximal performing sit-up, sitting, prone position.

References joint range of motion points determined on a) shoulder flexion on arm epicondyle proximal, b) shoulder extension on arm epicondyle proximal, c) shoulder abduction on arm epicondyle proximal, d) shoulder adduction on arm epicondyle proximal, e) shoulder lateral-internal rotation on styloid process proximal, f) shoulder medial-external rotation on styloid process proximal, g) elbow flexion on proximal styloid process, h) elbow extension on proximal styloid process, ı) elbow supination on lateral styloid process, j) elbow pronation on lateral styloid process, k) wrist flexion on metacarpophalangeal joint proximal, l) wrist extension on metacarpophalangeal joint proximal, m) wrist abduction on metacarpophalangeal joint proximal, n) wrist adduction on metacarpophalangeal joint proximal, o) hip flexion on femoral epicondyle nearest, p) hip extension on femoral epicondyle nearest, r) hip abduction on lateral epicondyle nearest, s) hip adduction on lateral epicondyle nearest, t) knee flexion on malleoli proximal, u) knee extension on malleoli proximal, v) ankle dorsi flexion on metacarpophalangeal joint proximal, w) ankle plantar flexion on metacarpophalangeal joint proximal, x) ankle inversion on lateral malleoli proximal, y) ankle eversion on lateral malleoli proximal (Andrews et al., 1996).

Vertical jumps

Countermovement jump (CMJ) as highest jump concentric explosive vertical jump at 180 degree knee flexed, non-arm swing countermovement jump (aCMJ) as highest jump as knee flexed and arm on hip, vertical jump

(VJ) in specific technique, single leg vertical jump (SLVJ) performed on right or left leg at 180 degree knee flexed as countermovement jump. Each participant tested on 3 jump session permissions 10 s recovery (Inf, SW03, Photocell Vertical Jump Device, TR) (Kahraman, 2023).

Calisthenics
Sit-up started knee locked position and hand in ground, their chest nearest ground then elbow flexion lifting proper movement phase performed controlled during 30 second (Clemons, 2019). Push-up tested on ground position by knee locked, shoulder optimal range of motion, hand in ground then longitudinal body lowered in chest controlled way. Triceps dips on parallel bench, feet in ground and arms 90 degree flexed then performed extension position (Delavier, 2001).

Flexibility
Trunk and hamstring flexibility tested on box bench to evaluate knee and feet flatted with hand palm extended during box as maximum flexion possible by protecting 5 s proper position (Muyor et al., 2014).

Agility and speed
Test started initially on 10 m distance pointed then agility and speed maximal performance as possible highest speed about runner exactly 42 m, by covering the distance, the vertical jump performed through a step to the side reached, first to the right and returned to the start point, then non-stop by covering the same distance and taking a step to the left performed vertical jump (Chronometer, Kalenji).

Handgrip
Strength of right and left hand tested one handgrip device as possible maximum force reaction with 5 s contraction position.

Auxotonic resistance training
Auxotonic resistance training included in isotonic + isometric combination exercises; 1) Push-up, 2) Squat, 3) Triceps dips, 4) Calf raise, 5) Abdominal crunch, 6) Superman plank performed on the over 8 week and per week 2 day at 1 hour. Auxotonic training intensities respectively, first and second week at 50% low intensity, 3x8 rep, isom contraction 5 s, 15 s recovery, rop 30x4 rep, third and four week at 60% moderate intensity, 3x10 rep, isom contraction 7 s, 15 s recovery, rop 30x5 rep, five week at 70% moderate intensity, 3x12 rep, isom contraction 8 s, 30 s recovery, six week at 75% moderate-high intensity, 3x12 rep, isom contraction 8 s, 30 s recovery, seven week at 85% high intensity, 4x12 rep, isom contraction 10 s, 30 s recovery, and eight week at 90% high intensity, 4x12 rep, isom contraction 10 s, 30 s recovery. Whereas isotonic training was formed on isotonic contraction without isom seconds.

Statistical analysis
Population sample size using G. Power to determine statistical analysis. Two variable evaluations to detected d = 0.67 effect size used one Paired-T test after normality test to comparison. 1RM test, activforce strength test and power test comparison calculated on T-test. In this way, significant priority collocated alpha level ($p < .05$). Effect size using confidence interval of descriptors obtained from <0.25 = large, 0.25-0.50 medium, 0.50-1.00 = large, >1.00 = very large (Rhea, 2004).

RESULTS

Primarily 1RM strength, activforce isometric strength, power test comparison outcomes provided on effect sizes for strength and power development. AUT and IKT compared to 1RM strength in result of long term linear periodization. Strength changes increase to AUT than IKT showed pre and post-test outcomes. AUT to post test showed mostly high development (Table 1, 2).

Table 1. 1RM strength outcomes comparison of AUT and IKT to pre and post-test.

1 TM TEST	Group	Pre – Post	t	*p*	ES
Wrist extension (kg)	AUT	10.57±2.08 – 12.50±2.50	-2.540	.026	0.83
Wrist abduction (kg)	IKT	11.34±2.99 – 12.30±3.30	-1.100	.293	trival
	AUT	5.03±0.92 – 7.11±0.93	-8.035	.000	2.24
Wrist adduction (kg)	IKT	5.19±0.69 – 5.00±0.00	1.000	.337	trival
	AUT	4.84±0.55 – 6.34±1.29	-4.356	.001	1.51
Trunk lateral flexion (kg)	IKT	6.00±1.54 – 5.80±1.49	1.000	.337	trival
	AUT	21.15±1.65 – 24.23±1.57	-6.121	.000	1.91
Upper rowing (kg)	IKT	22.03±2.38 – 23.26±1.20	-1.705	.114	trival
	AUT	36.69±6.40 – 38.42±4.19	-1.021	.327	trival
	IKT	39.69±7.07 – 37.53±4.77	1.255	.233	trival
Triceps press down (kg)	AUT	28.30±7.21 – 43.03±8.98	-5.713	.000	1.80
	IKT	25.30±5.54 – 30.53±5.66	-4.305	.001	0.93
Hip flexion (kg)	AUT	18.53±4.40 – 35.19±12.43	-4.963	.000	1.78
	IKT	18.07±3.83 – 41.53±15.46	-6.151	.000	2.08
Hip extension (kg)	AUT	18.46±6.99 – 31.53±7.74	-4.155	.001	1.77
	IKT	21.15±6.50 – 25.38±4.31	-1.877	.085	trival
Ankle dorsi flexion (kg)	AUT	15.03±6.33 – 19.23±5.21	-3.410	.005	0.72
	IKT	17.15±5.28 – 12.92±3.52	2.724	.018	-0.94
Ankle plantar flexion (kg)	AUT	17.53±4.78 – 22.30±4.38	-2.592	.024	1.04
	IKT	15.38±4.31 – 15.76±4.93	-0.365	.721	trival
Ankle inversion (kg)	AUT	23.07±6.30 – 31.30±5.05	-5.508	.000	1.44
Ankle eversion (kg)	IKT	19.61±5.18 – 23.46±9.65	-1.443	.175	trival
	AUT	27.50±7.90 – 31.92±7.22	-2.945	.012	0.58
Biceps curl (kg)	IKT	24.23±5.71 – 25.38±9.00	-0.454	.658	trival
	AUT	16.34±2.19 – 19.42±2.53	-4.382	.001	1.30
	IKT	14.80±2.38 – 16.15±3.90	-2.214	.047	0.41
Shoulder pull down (kg)	AUT	33.46±5.54 – 32.50±5.95	0.483	.638	trival
	IKT	31.53±5.54 – 29.23±4.93	1.389	.190	trival
Chest press (kg)	AUT	30.00±7.35 – 35.80±4.53	-2.768	.017	0.95
Hip abduction (kg)	IKT	33.19±10.82 – 33.57±9.01	-0.136	.894	trival
	AUT	47.57±8.34 – 52.84±9.90	-2.356	.036	0.57
Hip adduction (kg)	IKT	45.42±5.87 – 49.65±8.10	-2.157	.052	trival
	AUT	47.23±8.72 – 58.42±9.02	-3.964	.002	1.26
Leg curl (kg)	IKT	39.73±8.60 – 50.76±4.73	-4.285	.001	1.61
	AUT	31.92±9.25 – 40.00±5.40	-3.228	.007	1.06
Leg extension (kg)	IKT	39.23±12.22 – 38.19±6.25	0.257	.801	trival
	AUT	60.76±17.05 –72.30±10.12	-2.024	.066	trival
Calf raise (kg)	IKT	37.30±19.43 – 62.30±19.32	-3.536	.004	1.29
	AUT	40.76±9.54 – 47.11±6.75	-3.434	.005	0.76
Abdominal hyperextension (kg)	IKT	34.46±11.01 – 34.23±10.37	0.069	.946	trival
	AUT	16.07±4.35 – 21.30±4.97	-4.500	.001	1.11
Trunk flexion (kg)	IKT	18.07±5.60 – 18.84±5.82	-0.365	.721	trival
	AUT	26.73±7.63 – 31.53±9.65	-2.900	.013	0.55
Trunk extension (kg)	IKT	24.23±4.93 – 26.15±8.69	-1.000	.337	trival
	AUT	28.07±7.64 – 29.03±7.87	-0.595	.563	trival
	IKT	28.84±6.17 – 22.69±6.32	2.484	.029	trival
Trunk rotation (kg)	AUT	16.73±4.49 – 21.73±5.34	-5.326	.000	1.01
	IKT	16.15±6.81 – 14.61±3.79	0.772	.455	trival

Table 2. 1RM strength outcomes comparison of AUT and IKT to post test.

1 RM TEST	Group	Test	t	*p*	ES
Wrist dorsal flexion (kg)	AUT IKT	20.76 ± 4.00 20.00 ± 4.56	0.457	.652	trivial
Wrist plantar flexion (kg)	AUT IKT	12.50 ± 2.50 12.30 ± 3.30	0.167	.868	trivial
Wrist abduction (kg)	AUT IKT	7.11 ± 0.93 5.00 ± 0.00	8.124	.000	3.20
Wrist adduction (kg)	AUT IKT	6.34 ± 1.29 5.80 ± 1.49	0.981	.336	trivial
Trunk lateral flexion (kg)	AUT IKT	24.23 ± 1.57 23.26 ± 1.20	1.750	.093	trivial
Upper rowing (kg)	AUT IKT	38.42 ± 4.19 37.53 ± 4.77	0.502	.620	trivial
Triceps press down (kg)	AUT IKT	43.03 ± 8.98 30.53 ± 5.66	4.244	.000	1.66
Hip flexion (kg)	AUT IKT	35.19 ± 12.43 41.53 ± 15.46	1.153	.260	trivial
Hip extension (kg)	AUT IKT	31.53 ± 7.74 25.38 ± 4.3	2.504	.019	0.98
Ankle dorsi flexion (kg)	AUT IKT	19.23 ± 5.21 12.92 ± 3.52	3.614	.001	1.41
Ankle plantar flexion (kg)	AUT IKT	22.30 ± 4.38 15.76 ± 4.93	3.571	.002	1.40
Ankle inversion (kg)	AUT IKT	31.30 ± 5.05 23.46 ± 9.65	2.595	.016	1.01
Ankle eversion (kg)	AUT IKT	31.92 ± 7.22 25.38 ± 9.00	2.042	.052	trivial
Biceps curl (kg)	AUT IKT	19.42 ± 2.53 16.15 ± 3.90	2.534	.018	0.99
Shoulder pull down (kg)	AUT IKT	32.50 ± 5.95 29.23 ± 4.93	1.525	.140	trivial
Chest press (kg)	AUT IKT	35.80 ± 4.53 33.57 ± 9.01	0.797	.433	trivial
Hip abduction (kg)	AUT IKT	52.84 ± 9.90 49.65 ± 8.10	0.899	.377	trivial
Hip adduction (kg)	AUT IKT	58.42 ± 9.02 50.76 ± 4.73	2.707	.012	1.06
Leg curl (kg)	AUT IKT	40.00 ± 5.40 38.19 ± 6.25	0.789	.438	trivial
Leg extension (kg)	AUT IKT	72.30 ± 10.12 62.30 ± 19.32	1.653	.111	trivial
Calf raise (kg)	AUT IKT	47.11 ± 6.75 34.23 ± 10.37	3.571	.001	1.47
Abdominal hyperextension (kg)	AUT IKT	21.30 ± 4.97 18.84 ± 5.82	1.158	.258	trivial
Trunk flexion (kg)	AUT IKT	31.53 ± 9.65 26.15 ± 8.69	1.494	.148	trivial
Trunk extension (kg)	AUT IKT	29.03 ± 7.87 22.69 ± 6.32	2.265	.033	0.88
Trunk rotation (kg)	AUT IKT	21.73 ± 5.34 14.61 ± 3.79	3.915	.001	1.53

Activforce isometric strength outcomes provided effect size of AUT and IKT to result muscular isom potential activation. AUT and IKT compared to activforce measurement showed on peak and average force changes increase to AUT and IKT similar to pre and post-test outcomes. AUT and IKT post-test comparison concluded non effect sizes (Tables 3,4).

Table 3. Activforce isometric strength comparison of AUT to pre and post peak and average force.

Isom force		Pre – Post	t	p	ES
Shoulder flexion (N)	Peak	111.95 ± 18.11 129.05 ± 14.54	-3.316	.006	1.04
	Avg	94.99 ± 12.60 108.14 ± 13.29	-3.416	.005	1.01
Shoulder extension (N)	Peak	103.33 ± 25.66 142.57 ± 31.00	-4.850	.000	1.37
	Avg	87.83 ± 21.64 113.10 ± 22.84	-3.261	.007	1.13
Shoulder abduction (N)	Peak	123.00 ± 25.68 135.17 ± 23.96	-2.000	.069	trivial
	Avg	100.02 ± 22.23 113.18 ± 24.84	2.206	.048	0.55
Shoulder adduction (N)	Peak	100.21 ± 21.65 138.89 ± 23.10	-4.633	.001	1.72
	Avg	77.55 ± 18.30 116.07 ± 20.18	-7.134	.000	1.99
Shoulder lateral/internal rotation (N)	Peak	117.28 ± 37.56 157.15 ± 26.59	-4.202	.001	1.22
	Avg	88.59 ± 23.36 131.51 ± 30.12	-5.249	.000	1.59
Shoulder medial/external rotation (N)	Peak	97.31 ± 20.49 123.27 ± 20.4	-3.209	.008	1.26
	Avg	80.83 ± 18.54 104.54 ± 16.91	-3.150	.008	1.33
Elbow flexion (N)	Peak	128.50 ± 24.77 158.76 ± 43.00	-3.168	.008	0.86
	Avg	107.27 ± 16.56 128.83 ± 36.16	-2.664	.021	0.76
Elbow extension (N)	Peak	124.99 ± 33.27 170.36 ± 30.54	-4.264	.001	1.42
	Avg	100.60 ± 27.37 141.80 ± 28.69	-4.320	.001	1.46
Elbow supination (N)	Peak	87.86 ± 21.05 123.89 ± 42.40	-2.932	.013	1.07
	Avg	92.31 ± 31.21 104.44 ± 40.40	-2.875	.014	0.33
Elbow pronation (N)	Peak	116.75 ± 45.63 121.64 ± 41.78	-0.433	.673	trivial
	Avg	74.77 ± 15.31 104.53 ± 36.20	-1.331	.208	1.07
Wrist flexion (N)	Peak	88.91 ± 26.05 102.49 ± 29.88	-2.143	.053	trivial
	Avg	77.30 ± 24.02 90.78 ± 29.13	-2.199	.048	0.50
Wrist extension (N)	Peak	71.13 ± 18.49 80.41 ± 13.90	-1.945	.076	trivial
	Avg	58.87 ± 14.25 65.50 ± 12.40	-1.791	.099	trivial

Wrist adduction (N)	Peak	70.83 ± 19.19 104.47 ± 22.85	-4.955	.000	1.59
	Avg	58.41 ± 15.58 88.55 ± 21.70	-4.666	.001	1.59
Wrist abduction (N)	Peak	93.23 ± 23.20 103.48 ± 19.47	-1.273	.277	trivial
	Avg	82.72 ± 18.83 91.73 ± 21.51	-1.130	.281	trivial
Hip flexion (N)	Peak	159.59 ± 28.87 198.17 ± 33.01	-4.762	.000	1.24
	Avg	134.04 ± 20.24 166.14 ± 23.25	-5.756	.000	1.47
Hip extension (N)	Peak	154.71 ± 73.28 239.53 ± 59.13	-4.041	.002	1.27
	Avg	122.43 ± 42.66 187.69 ± 53.91	-3.489	.004	1.34
Hip abduction (N)	Peak	126.63 ± 42.75 167.04 ± 40.38	-4.269	.001	0.97
	Avg	109.38 ± 41.14 134.64 ± 36.00	-3.204	.008	0.65
Hip adduction (N)	Peak	119.73 ± 19.59 169.02 ± 39.87	-4.951	.000	1.56
	Avg	100.31 ± 16.22 131.40 ± 38.58	-3.438	.005	1.05
Knee flexion (N)	Peak	136.57 ± 37.95 195.91 ± 49.55	-3.456	.005	1.34
	Avg	114.40 ± 30.29 157.04 ± 41.63	-2.640	.022	1.17
Knee extension (N)	Peak	180.43 ± 55.57 175.74 ± 42.40	0.340	.740	trivial
	Avg	148.80 ± 50.96 143.84 ± 39.25	0.341	.739	trivial
Ankle dorsi flexion (N)	Peak	96.45 ± 32.87 124.67 ± 25.94	-3.969	.002	0.95
	Avg	75.74 ± 20.51 110.21 ± 27.38	-5.535	.000	1.42
Ankle plantar flexion (N)	Peak	75.87 ± 10.80 121.57 ± 23.00	-5.668	.000	2.54
	Avg	57.62 ± 9.52 104.102 ± 21.97	-6.607	.000	2.74
Ankle inversion (N)	Peak	83.67 ± 17.10 101.70 ± 17.39	-2.553	.025	1.04
	Avg	70.35 ± 14.90 82.10 ± 17.57	-1.995	.069	trivial
Ankle eversion (N)	Peak	83.78 ± 26.85 95.56 ± 17.94	-2.000	.069	trivial
	Avg	70.81 ± 25.69 75.76 ± 12.46	-0.844	.415	trivial

Table 4. Activforce isometric strength comparison of IKT to pre and post peak and average force.

Isom force		**Pre – Post**	**t**	***p***	**ES**
Shoulder flexion (N)	Peak	95.15 ± 24.53 129.13 ± 21.45	-3.649	.003	1.47
	Avg	71.44 ± 16.96 104.87 ± 15.87	-5.738	.000	2.05

Shoulder extension (N)	Peak	93.38 ± 18.12 144.44 ± 35.07	-5.310	.000	1.82
	Avg	78.69 ± 15.48 110.97 ± 18.77	-5.843	.000	1.87
Shoulder abduction (N)	Peak	96.74 ± 19.98 133.95 ± 21.14	-5.560	.000	1.80
	Avg	83.78 ± 21.42 109.71 ± 19.87	-3.577	.004	1.25
Shoulder adduction (N)	Peak	83.46 ± 21.46 136.14 ± 18.82	-7.886	.000	2.61
	Avg	69.33 ± 18.52 109.49 ± 11.80	-7.952	.000	2.58
Shoulder lateral/internal rotation (N)	Peak	92.58 ± 32.36 148.38 ± 38.74	-4.882	.000	1.56
	Avg	75.85 ± 28.27 117.16 ± 32.09	-3.600	004	1.36
Omuz medial/external rotation (N)	Peak	78.41 ± 17.94 121.09 ± 22.96	-5.958	0.000	2.07
	Avg	66.08 ± 15.44 97.43 ± 12.87	-6.346	.000	2.20
Elbow flexion (N)	Peak	132.69 ± 42.27 139.38 ± 38.26	-0.596	.562	trivial
	Avg	101.71 ± 34.80 113.37 ± 25.61	-1.119	.285	0.38
Elbow extension (N)	Peak	102.56 ± 32.06 162.86 ± 30.38	-5.177	.000	1.93
	Avg	84.37 ± 26.97 131.41 ± 22.56	-4.253	.001	1.89
Elbow supination (N)	Peak	84.21 ± 24.40 137.53 ± 30.76	-5.310	.000	1.92
	Avg	66.93 ± 16.99 116.38 ± 24.02	-5.458	.000	2.37
Elbow pronation (N)	Peak	105.30 ± 26.65 125.50 ± 23.83	-2.145	.053	trivial
	Avg	84.52 ± 21.24 106.90 ± 18.60	-2.924	.013	1.12
Wrist flexion (N)	Peak	85.45 ± 18.50 110.89 ± 17.61	-4.167	.001	1.40
	Avg	71.01 ± 17.71 95.20 ± 15.90	-4.206	.001	1.43
Wrist extension (N)	Peak	85.28 ± 18.17 85.07 ± 24.52	0.025	.980	trivial
	Avg	69.28 ± 15.54 70.67 ± 20.16	-0.173	.865	trivial
Wrist adduction (N)	Peak	67.21 ± 19.43 99.95 ± 14.41	-4.613	.001	1.91
	Avg	56.30 ± 16.87 80.28 ± 10.75	-4.929	.000	1.69
Wrist abduction (N)	Peak	88.08 ± 43.10 121.63 ± 42.52	-2.056	.062	trivial
	Avg	70.49 ± 32.74 98.68 ± 32.84	-2.291	.041	0.85
Hip flexion (N)	Peak	139.86 ± 44.12 209.21 ± 41.19	-4.011	.002	1.62
	Avg	116.92 ± 39.27 169.77 ± 23.57	-4.384	.001	1.63

Hip extension (N)	Peak	124.75 ± 32.81 239.23 ± 41.97	-7.260	.000	3.06
	Avg	99.39 ± 33.97 182.75 ± 36.00	-5.534	.000	2.38
Hip abduction (N)	Peak	117.30 ± 28.33 169.44 ± 38.89	-4.601	.001	1.53
	Avg	95.06 ± 27.14 131.87 ± 29.90	-4.514	.001	1.28
Hip adduction (N)	Peak	100.67 ± 17.58 182.41 ± 48.88	-5.361	.000	2.22
	Avg	84.66 ± 17.27 143.31 ± 37.29	-4.932	.000	2.01
Knee flexion (N)	Peak	130.57 ± 23.66 194.90 ± 48.33	-4.130	.001	1.69
	Avg	108.20 ± 22.09 157.54 ± 39.27	-3.515	.004	1.54
Knee extension (N)	Peak	165.08 ± 46.67 177.44 ± 51.74	-0.844	.415	trivial
	Avg	136.70 ± 34.16 135.68 ± 27.24	0.110	.914	trivial
Ankle dorsi flexion (N)	Peak	86.73 ± 21.18 123.15 ± 29.66	-4.204	.001	1.41
	Avg	71.97 ± 19.77 107.29 ± 27.24	-4.408	.001	1.48
Ankle plantar flexion (N)	Peak	78.29 ± 20.79 123.41 ± 32.00	-4.203	.002	1.67
	Avg	60.32 ± 19.15 103.87 ± 25.76	-4.729	.000	1.91
Ankle inversion (N)	Peak	79.88 ± 17.24 106.06 ± 18.48	-4.063	.002	1.46
	Avg	65.97 ± 14.89 83.67 ± 17.80	-2.994	.011	1.07
Ankle eversion (N)	Peak	85.25 ± 8.81 100.08 ± 24.63	-2.184	.050	trivial
	Avg	70.63 ± 6.27 80.63 ± 16.80	-2.145	-2.145	trivial

Table 5. Power comparison of AUT to pre and post-test.

Power	**Group**	**Pre – Post**	**t**	***p***	**ES**
Sit-up	AUT	19.23 ± 2.24 – 21.53 ± 3.84	-2.540	.026	0.73
	IKT	17.69 ± 3.11 – 23.69 ± 4.30	-7.899	.000	1.59
Push-up	AUT	22.15 ± 9.33 – 23.38 ± 7.76	-0.686	.506	trivial
	IKT	12.61 ± 5.72 – 21.15 ± 8.89	-3.517	.004	1.14
Triceps dips	AUT	22.61 ± 7.48 – 26.07 ± 5.10	-2.347	.037	0.54
	IKT	21.38 ± 5.31 – 28.30 ± 6.71	-5.105	.000	1.14
Countermovement jump	AUT	24.11 ± 3.65 – 24.61 ± 3.59	-0.495	.629	trivial
	IKT	21.80 ± 6.95 – 23.84 ± 5.91	-1.204	.252	trivial
Countermovement jump (90°)	AUT	27.15 ± 5.97 – 27.92 ± 6.10	-1.059	.310	trivial
	IKT	22.53 ± 3.09 – 24.57 ± 5.96	0.143	.889	trivial
Vertical jump	AUT	28.92 ± 4.59 – 29.23 ± 4.24	-0.362	.724	trivial
	IKT	24.57 ± 5.96 – 24.38 ± 3.04	0.101	.921	trivial
Single leg vertical jump (right)	AUT	11.38 ± 3.81 – 12.30 ± 2.95	-1.369	.196	trivial
	IKT	9.69 ± 2.98 – 10.38 ± 1.75	-0.962	.355	trivial
Single leg vertical jump (left)	AUT	11.84 ± 3.26 – 12.69 ± 3.79	-1.058	.311	trivial
	IKT	8.00 ± 1.87 – 9.53 ± 1.80	-2.857	.014	0.83

Flexibility	AUT IKT	24.23 ± 6.83 – 25.76 ± 6.62 21.30 ± 6.47 – 24.76 ± 7.10	-2.922 -3.212	.013 .007	0.22 0.50
Handgrip (right)	AUT IKT	28.38 ± 3.82 – 27.99 ± 3.60 26.19 ± 3.87 – 27.79 ± 3.06	0.368 -1.738	.719 .108	trivial trivial
Handgrip (left)	AUT IKT	27.61 ± 3.11 – 28.24 ± 2.85 25.71 ± 3.74 – 25.53 ± 3.56	-0.885 0.147	.394 .886	trivial trivial
Agility	AUT IKT	14.47 ± 0.88 – 14.28 ± 0.87 15.11 ± 0.85 – 14.56 ± 0.72	0.813 2.839	.432 .015	0.21 0.69

Table 6. Power outcomes comparison of AUT and IKT to post test.

Power	Group	Pre – Post	t	*p*	ES
Sit-up	AUT IKT	21.53 ± 3.84 23.69 ± 4.30	-1.345	.191	trivial
Push-up	AUT IKT	23.38 ± 7.76 21.15 ± 8.89	0.681	.502	trivial
Triceps dips	AUT IKT	26.07 ± 5.10 28.30 ± 6.71	-0.954	.350	trivial
Countermovement jump	AUT IKT	24.61 ± 3.59 23.84 ± 5.91	0.401	.692	trivial
Countermovement jump (90°)	AUT IKT	27.92 ± 6.10 22.38 ± 3.79	2.778	.010	1.09
Vertical jump	AUT IKT	29.23 ± 4.24 24.38 ± 3.04	3.345	.003	1.31
Single leg vertical jump (right)	AUT IKT	12.30 ± 2.95 10.38 ± 1.75	2.017	.055	trivial
Single leg vertical jump (left)	AUT IKT	12.69 ± 3.79 9.53 ± 1.80	0.371	.714	trivial
Flexibility	AUT IKT	25.76 ± 6.62 24.76 ± 7.10	-1.880	.072	trivial
Handgrip (right)	AUT IKT	27.99 ± 3.60 27.79 ± 3.06	2.136	.043	0.05
Handgrip ((left)	AUT IKT	28.24 ± 2.85 25.53 ± 3.56	-0.907	.373	trivial
Agility	AUT IKT	14.47 ± 0.88 15.11 ± 0.85	0.152	.880	trivial

Power outcomes showed a high significant of power improvement in calisthenic, vertical jump, flexibility and hand strength measurements before and after auxotonic resistance training to AUT and IKT. According to AUT IKT, vertical jump performance showed a high effect size in the post-test comparison (Tables 5,6).

DISCUSSION

Auxotonic resistance training performed to evaluate on strength and power changes of young volleyball players over 8 weeklong term linear periodization. Performance research process of young volleyball players had included some maximal strength, isometric strength, calisthenic, power, flexibility and agility tests. The comparison of AUT and IKT after auxotonic resistance training reported 1RM strength was very large effect size according to AUT IKT. Auxotonic resistance training continued development of strength without changing mechanic range of motion during linear periodization, however, current research showed that mechanical range of motion limited by other measurements and insufficient maximal force production to subsequent strength development (Azeem et al., 2022). On the other hand, auxotonic resistance training develops muscle mechanic isometric contraction potential to maximal strength development, however, maximal strength not developed on mechanic range of motion by isometric time-dependent force. That is, the potential peak and average force related isometric muscle contraction should be limited to 5-7 s for the lower compartment (Comfort et al., 2022). Furthermore, some evidence to combination isotonic + isometric contraction in 1RM bench press of isometric 14.23%, and isotonic 35.45% proper strength planning on compartment muscle limited range of motion, thus potential isometric peak and average muscle force must be constructed for strength increase based time-dependent trials after resistance exercise (Azeem et al., 2022; Comfort et al., 2022). Similarly, research outcomes observed that the use of isometric or isotonic exercise in incorrect planning resulted in similar strength outcomes especially for energy potential production of specific muscle group did not provide strength increases via auxotonic resistance training. In this condition, performance outcomes had relationship auxotonic resistance training outcomes for muscle contraction mechanics based on the combination of muscle strength increases with isometric muscle contraction, supporting the potential fast contraction force production of the muscle. Within isotonic muscle contractions in the joint range of motion that therefore, static and dynamic forces in AUT provide more meaningful results than IKT. Auxotonic resistance training was highly effective resistance training method during long term training periods including isometric muscle contraction periods. It was seen in one study that only the mechanical range region reported shoulder region muscle force was evaluated in isometric activation, but in our study, isometric contraction sessions supported the resistance training period in both the upper and lower compartment regional muscles (Karagiannapoulos et al., 2022). Therefore, increase of muscle strength are variable, regional compartment studies not used in different auxotonic exercises for sports performance athletes for peak and average effects of actual strength should be evaluated specifically for each athlete. Activforce isometric results AUT and IKT were compared and the reason why no significant outcomes were obtained is that similar age and strength characteristics are not the same for individual evaluations in isometric muscle contraction activations. The reason why power improves in auxotonic resistance training is that it includes high repetition time-dependent exercises (4). At the same time, more effective regional auxotonic training changed the performance values in these strength test parameters, especially strength.

CONCLUSİON

This research determined the effect of auxotonic resistance training on muscle strength and power in young volleyball players. However, muscle strength tests and power performance were specific to athletes and different results were obtained compared to other studies using auxotonic resistance training. In the research, auxotonic resistance training was in isometric and isotonic combination and was examined in two separate groups for performance changes. Therefore, muscle strength gains had similar effects in both groups on 1RM measurements. Although the AUT and IKT were similar in the peak and average isometric values where muscle strength was examined regionally, a larger effect size was observed in the IKT. Likewise, after auxotonic resistance training, the calisthenic, flexibility and agility results of the AUT and IKT were similar. AUT achieved more significant results in jumping performance than the IKT group. Therefore, as a result of the research, planning auxotonic resistance training at a level that will increase isometric and isotonic performances, which is a combination of muscle contraction, improves muscle strength and power parameters individually in athletes. In the research, indeed auxotonic resistance training improves muscle strength 1RM performances and isometric muscle contraction potential when applied at any time during annual training periods. For this reason, our research shows that auxotonic resistance training should be implemented in young athletes during the periods when annual muscle strength and power training is planned. At the same time, there is a greater need for studies that will demonstrate high jumping performance when isometric muscle contraction combinations, which are easier and simpler than other strength training for muscle strength increases, are combined with technical training.

AUTHOR CONTRIBUTIONS

For this study showed any conflict of interest, funding preparation, no ethic statement. All rights hidden in ethic committee and Helsinki declarations. Authors; YK and FK have research design, methodological approach, and assay structure.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

DATA AVAILABILITY

Data are available under reasonable request to corresponding author. Included both original data generated in the study research and supports of results and analyses.

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SUSTAINABILITY & SPORTS SCIENCE JOURNAL

ORIGINAL ARTICLE

Key requirements for implementing digital governance in Algerian sports institutions

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ABSTRACT

The present study aims to determine the human, technical, and legislative prerequisites for implementing electronic governance in Algerian sports institutions. Employing a descriptive methodology, we selected a purposive sample of 30 employees from the Youth and Sports Directorate in the state of Souk Ahras, using a questionnaire as the primary research tool. Our findings indicate that there are specific human, technical, and legislative requirements necessary for the successful implementation of electronic governance in sports institutions in Algeria.
Keywords: Sport management, Digital governance, Sports institutions, Sports directorate.

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INTRODUCTION

The topic of sports management has gained widespread acceptance among researchers and specialists in recent times, largely due to the advancement of sports programs within institutions amidst technological developments. These technological advancements have significantly contributed to the exploration of methods to enhance administrative work.

As sports organizations are increasingly required to adopt a more professional, transparent, and accountable approach to their operations, it has become crucial for students, researchers, and professionals in the field to understand the principles of governance and how to effectively implement them (O'Boyle & Bradbury, 2013).

Chappelet (2018) highlights that "*Since the beginning of the twenty-first century, governmental and intergovernmental bodies, national and international sport governing bodies, and academics have provided numerous lists — more than 30 in total — of governance principles for sports organizations*." (p. 724) These principles pertain to the authority and powers granted to monitor, direct, manage, and control the strategic performance of a sports organization, ensuring compliance with relevant regulations and laws while considering internal dynamics and external environments (Sungho et al., 2024, p. 280).

This also encompasses the public sector's use of information and communications technology to "*enhance the delivery of information and services, foster citizen participation in decision-making, and increase government accountability, transparency, and effectiveness*" (Palvia & Sharma, 2007, p. 3).

Over the past two decades, digital governance has evolved from a focus on the direct application of technology in public administration to an interdisciplinary understanding of governance and a comprehensive, integrative view of administrative processes (Janowski, 2015).

Governance involves the application of information technology in government operations to enhance the delivery of public services to individuals, organizations, and users of other government services (Twizeyimana & Andersson, 2019, p. 167).

It also contributes to the effective management of resources, thereby improving the use of natural resources and mitigating potential future harm (Conceição & Lopes, 2022, p. 881).

In light of this context, this research paper aims to assess the extent to which digital governance requirements are implemented in sports institutions in Algeria and to identify the most critical requirements for digital governance within these institutions.

MATERIAL AND METHODS

The research process involved targeted searches within digital governance sites, with all records imported from these sites undergoing a thorough, two-stage review. Initially, the records were assigned to two experts in the field for detailed examination and feedback.

In the first stage, titles and abstracts of all collected articles and published research were evaluated. The second stage involved a full-text review of the research papers by five reviewers. This process ensured that

25% of the excluded studies were assessed for quality control in peer-reviewed research, ensuring they were relevant to the research topic.

The study utilized empirical data with both descriptive and inferential statistical analysis, chosen as the most suitable method for achieving the research objectives.

Procedures

The researchers used a questionnaire consisting of 15 statements divided into four sections:

- Section One: Human Requirements (5 statements).
- Section Two: Technical Requirements (5 statements).
- Section Three: Legislative Requirements (5 statements).

The questionnaire was designed with closed-ended questions using a five-point Likert scale, named after psychologist Rensis Likert, asking respondents to indicate their level of agreement with each statement.

The study population comprised employees of the Youth and Sports Directorate of Souk Ahras, with a sample size of 30 workers selected randomly. The sample includes 10 workers under 45 years old and 20 workers over 45 years old. Table 1 details the sample distribution by age:

Table 1. Sample distribution by age variable.

Age	Repetition	Percentage
Under 45 years old	10	33.33
Over 45 years old	20	66.66
Total	30	100

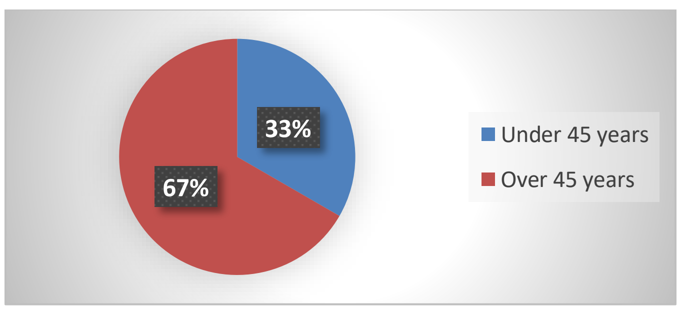

Figure 1. Distribution of sample members.

The study population comprised employees of the Youth and Sports Directorate of Souk Ahras, with a sample size of 30 workers selected randomly. The sample includes 10 workers under 45 years old and 20 workers over 45 years old.

Validity of the tool

- *Face Validity*: On March 15, 2024, the researchers presented the preliminary version of the questionnaire to a panel of experienced experts in the field of scientific research and qualified in the study's subject area for their evaluation.
- *Internal Consistency Validity*: After establishing face validity, Pearson's correlation coefficient was employed to assess the construct validity and internal consistency of the instrument, as well as to determine its internal coherence. Table 2 illustrates this.

Table 2 shows the correlation coefficients between each item in the digital governance requirements section for sports institutions and the overall score for the section. The correlations ranged from .865 to .976, indicating statistical significance at the .01 to .05 level. This demonstrates that the items in this section are valid for measuring what they are intended to.

Table 2. Correlation coefficients between each item in the digital governance requirements section for sports institutions and the overall score of the items.

Number	Axe	Correlation coefficient	Sig.
01	Requirements for implementing digital governance in sports institutions	.865 - .976	.01

Reliability of the instrument

Reliability is crucial for determining the validity of any test or questionnaire.

Split-Half method

The researchers assessed the reliability using the split-half method on the study sample. The questionnaire was divided into two halves (odd-numbered items and even-numbered items), and the correlation coefficient between the scores of the odd-numbered and even-numbered questions was calculated. This correlation coefficient was then adjusted using the Spearman-Brown formula:

$$\text{Adjusted correlation coefficient} = 2\,r / 1+r$$

where r is the correlation coefficient.

Table 3. Split-half reliability of the questionnaire items.

Questionnaire themes	Number of statements	Split half method	Stability coefficient	Spearman-Brown correlation coefficient
Requirements for implementing digital governance in sports institutions	15	08 07	.985 .989	.993

Statistical analysis

The researchers used the statistical program SPSS (Statistical Package for the Social Sciences, version 22).

RESULTS

Are there requirements for implementing digital governance in sports institutions in Algeria?

To answer this question, the arithmetic mean, standard deviation, frequencies, and percentages were employed.

Table 4. Requirements for implementing digital governance in sports institutions in Algeria.

Number	Themes of statements	SMA	Standard deviation	Ranking
01	Human requirements	3.84	0.72	01
02	Technical requirements	3.67	0.84	02
03	Legislative requirements	3.45	0.96	03
All axis statements		3.65	0.84	

Source: Outputs of SPSS version 22.

Table 4 illustrates that the mean values of responses from the sample regarding the requirements for implementing digital governance in sports institutions in Algeria ranged from 3.45 to 3.84, with standard deviations between 0.72 and 0.96.

Digital governance requirements in Algerian sports institutions
Based on frequencies, percentages, and the ranking of mean values and standard deviations of the sample responses, the results are as follows:

Human requirements
ranked first with a mean of 3.84 and a standard deviation of 0.65. This indicates that digital governance in sports institutions primarily relies on human resources, which are essential for managing information technology within the organization.

Technical requirements
ranked second with a mean of 3.67 and a standard deviation of 0.84. This suggests that digital governance depends on providing internet access, websites, and computer equipment to achieve institutional goals and progress.

Legislative requirements
Ranked last with a mean of 3.45 and a standard deviation of 0.96. This reflects that digital governance in Algeria lacks legal frameworks and legislative texts to effectively implement digital governance in sports institutions due to the absence of relevant legal provisions.

The overall mean score for the requirements of implementing digital governance in sports institutions in Algeria was 3.65 with a standard deviation of 0.84, indicating an acceptable level of implementation.

DISCUSSION

The statistical analysis of the data collected in this study revealed that "*Human Requirements*" is the most significant factor for implementing digital governance in sports institutions, with a mean of 3.84 and a standard deviation of 0.65. The development of external digitization may significantly reduce the number of employees, potentially marginalizing human resources. Despite the lack of a similar counterpart in human resource management, the concept of digital disruption can still be applied (Strohmeier, 2020, p. 351).

"*Technical Requirements*" ranked second with a mean of 3.67 and a standard deviation of 0.84. In the context of rapid technological advancement, changing societal needs, and unexpected crises, it is crucial for governments to effectively use technologies and digital data to enhance productivity and flexibility in public sectors. Establishing the correct institutional arrangements, coordination mechanisms, and policy tools is essential for supporting long-term transformations and overcoming shifting political priorities (OECD, 2021, p. 8).

"*Legislative Requirements*" ranked last with a mean of 3.45 and a standard deviation of 0.96, indicating that legislative texts are insufficient or lacking in the sports sector, which hinders the effective implementation of digital governance.

General hypothesis
"*There is an acceptable level of digital governance requirements implementation in sports institutions in Algeria*," with a mean of 3.65 and a standard deviation of 0.84, which is considered acceptable.

CONCLUSIONS

The findings suggest that implementing digital governance in Algerian sports institutions requires human resources capable of adapting to technological advancements, such as data security and website management. Additionally, effective digital governance needs the development of legal texts to protect individuals and employees in the sports sector. The study's key results are as follows:

- *Human Requirements*: The most critical factor for implementing digital governance, with a mean of 3.84 and a standard deviation of 0.65.
- *Legislative Requirements*: The least addressed, with a mean of 3.45 and a standard deviation of 0.96, due to weak or nonexistent legal provisions.
- *Overall Implementation*: There is an acceptable level of digital governance implementation in sports institutions in Algeria, with a mean of 3.65 and a standard deviation of 0.84.

AUTHOR CONTRIBUTIONS

The authors collected, analyzed, and processed the data for this study. The first author proposed the overall study framework and theoretical frameworks and analyzed the data, while the second author was responsible for data collection and analysis.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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SUSTAINABILITY & SPORTS SCIENCE JOURNAL

ORIGINAL ARTICLE

Quantitative estimation of the coefficient of variation for explosive force tests using Myotest and Sergeant Test: Field study on M'sila football teams "*less than 17 years old*"

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ABSTRACT

This study aims to quantify The Coefficient of Variation to test the explosive force of footballers' lower extremities using MYOTEST and Sargent test. Tests and measures are considered to be as major parts to take the right scientific decisions in the training process like diagnosis, evaluation, orientation and selection. To complete the study, the researcher used the descriptive method by applying the explosive force test for the lower extremities using the MYOTEST Device (Saut puissance), (Saut détente) and the classic method (Sargent Test) on a sample group of 33 players from M'sila football teams (MCM and WRM) and the study results were as follows: Dispersion in modern tests is less than in traditional tests; The use of modern technologies is more effective in evaluating explosive force of footballers' lower extremities in terms of coefficients of variation in comparison with traditional tests; The main difference between them is in the classification of normative levels of explosive force according to dispersion and uncertainty ratios.
Keywords: Technology, Innovation, Modern technologies, Explosive force, Test.

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INTRODUCTION

The interest and participation in sports globally have increased significantly. Advances in technology have played a key role in the growth of the sports industry, which now enjoys gross sales over $800 billion annually. The sporting goods industry has diversified and expanded, incorporating the different interests and needs of the athletes and consumers. Sport and technology today have become inseparable as the transfer and integration of knowledge from a wide range of disciplines and industries has generated a rapid technological change (Subic, et al., 2011).

Today, professional sports are characterized by the search for new paths concerning how an athlete or a team may apply new technologies and sports performance data to gain the cutting edge competitive ability that will elevate them to the top of the podium or to win major league or championship titles. Therefore, professional sports properties are left with massive data pools that (without giving away competitive sporting advantages) can be utilized to assist athletes and teams in monetizing on their relationships with commercial stakeholders. In reflections over why the application of technology and data is important in sports, there are clear benefits in terms of optimizing decision-making processes on and off the playing field and thus sporting quality. William Spearman notes that "*It's been a way for intelligent teams to gain a competitive Advantage to be able to use perhaps less money, less resources but still have a competitive team*."(Cortsen, & Rascher, 2018).

The field of sports is experiencing a very dynamic and intensive development, so the application of information technology is an important factor in its successful functioning. The main factor in the popularization of sports are modern technologies and the opportunities they provide to users. The development of modern technology has resulted in better conditions for both spectators and competitors. Through the development of new technologies, much has been done to improve the results, such as those visible in tennis, athletics and the like. Modern materials are used in the production of synthetic sports surfaces in athletics, so there is a great progress in the 100-meter race compared to the time when these races took place on clay, as well as sports equipment in the form of jerseys and shoes. Sports technologies have evolved for human needs and goals. Technology in sports are also technical means by which athletes try to improve their sports result (Viduka, et al., 2021).

Today's sport world is becoming technologically advanced by combining natural athletic talent with advanced analytics and artificial intelligent to produce the best possible sporting outcomes. In so many ways, modern technology simplifies life and everyone defines technology in their own way. Throughout today's environment, where just about anything is more comfortable and available because of technical advancements in nearly every area of lifestyle. Everything in the world has both positive and negative impacts on both the living and society. In the 21st century, more people participate in sports than ever before. The previous U.N Secretary-General Kofi Annan said sport has become essentially a common language, putting citizens together irrespective of their roots, history, religious values or economic status.

Actually, sports make friendship each other and bonding each other not only for one country but also for whole world. Due to the demands of sports performance from spectator, the technological devises now take significant role. The difference between winning and losing games is often found in many sports and games, and in step-by-step team moves. As the sports industry's audience has grown alongside popularity, demand for research has increased. This is now above sports and gaming and now a billion dollar business. Researchers Roy et al. (2017) argued that in many aspects, new technology simplifies existence and each describes technology in their own way. In today's world, just about everything is more convenient and accessible because of technological advances across almost every aspect of lifestyle. Most people's lives have been enhanced and simplified by the latest technological developments. Although the real nature of sport resides in the skill of talented athletes, their performance can be dramatically improved by incorporating advanced technologies, guaranteeing competitive play and successful outcomes. Therefore, technology has the enormous capacity to improve performance and reduce the sports injury. In addition, it's unbelievable how technology has impacted sport. Using wearable technology, big data analytics, social media, and sensor technology has revolutionized the way sports are played, analysed, and enhanced in today's connected world. Pro athletes can gain more insight into their performance, improve training methods and raise their skills through various modern advances and apps (Sanjib Kumar Dey 2020).

Advances in technology have had a profound impact on sport including:

- Analysis of sport performance and enabling coaches to greatly improve the quality of feedback to players/athletes.
- Increase accuracy in time measurements of sport performance.
- Enabling referees, umpires and sport officials to make better decisions on rule infringements.
- Improvements in the design of sport equipment and apparel.
- Providing spectators with better viewing of sport performance (Gurubasavaraja.G 2020).

Soccer has increasingly evolved into a very athletic sport and soccer players are progressively becoming better athletes. Within a game, players repeatedly perform high-intensity actions in which muscle power is crucial. These bursts of explosive actions, such as accelerating, sprinting, kicking, tackling, turning, changing direction, and jumping may be completed over 500 times during the game. In particular, the decisive phases during the game require the player to perform at high intensity (Bangsbo et al. 2006; Rampinini et al. 2009). Speed, explosiveness, and the ability to intermittently repeat these high-intensity actions are fundamental to success in soccer (Cometti et al. 2001; Rampinini et al. 2009). Sprinting performance determines the outcome in match-winning actions (Cometti et al. 2001). A greater acceleration and sprinting ability increase the possibility to get to the ball first, to dribble past an opponent, to create or stop a goal-scoring opportunity.

Straight sprinting is the most frequent action in goal situations in soccer, for both the assisting and the scoring player (Faude et al. 2012; Haugen et al. 2014).

Soccer is a fast-paced game and speed and explosiveness have become increasingly crucial in game situations (Barnes et al. 2014; Haugen et al. 2014). In the last decade the number of sprints and sprint distance per game increased in the English Premier league by 85 percent and 35 percent respectively (Barnes et al. 2014). Top-class players perform more high-intensity sprint actions during a game and cover a greater distance at very high speeds (Mohr et al. 2003). Professional soccer players have also become progressively faster over the last 15 years (Haugen et al. 2012, 2014). Sprinting speed, agility performance, and repeated-sprint ability can distinguish the elite from the sub-elite players (Cometti et al. 2001; Kaplan et al. 2009; Rampinini et al. 2009; Rebelo et al. 2013) (Bram Swinnen 2016).

Tests and standards are one of the important bases for the planning, the follow up and the evaluation of the training programs in the field of football. As a result, before we go in details and analysis, the following question should be asked:

What is the qualitative estimation of the coefficients of variation by the use of Myotest in evaluating explosive force of footballers' lower extremities (less than 17 years old) in comparison to the application of Sargent test in terms of uncertainty ratios?

Hypothesis
The use of Myotest is more effective to evaluate the explosive force of footballers' lower extremities (less than 17 years old) in comparison to the application of Sargent test in terms of distrust ratios.

MATERIALS AND METHODS

The research problem imposed on us the descriptive method due to its suitability to the nature of the study to realize the aim of the research and to be sure from the hypothesis following the scientific steps.

Sergeant Jump Test
The objective of this test is to monitor the development of the athlete's elastic leg strength**.** To undertake this test you will require:

- Wall.
- 1 metre tape measure.
- Chalk.
- Assistant.

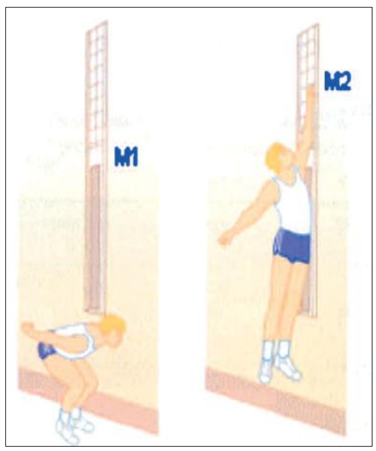

Figure 1. Sergeant Jump Test.

How to conduct the test:
The athlete:

- Chalks the end of his fingertips.
- Stands side onto the wall, keeping both feet remaining on the ground, reaches up as high as possible with one hand and marks the wall with the tips of the fingers (M1).
- From a static position jumps as high as possible and marks the wall with the chalk on his fingertips (M2).

The coach:
Measures the distance from M1 to M2.

The test can be performed as many times as the athlete wishes.

Analysis
Analysis of the result is by comparing it with the results of previous tests. It is expected that, with appropriate training between each test, the analysis would indicate an improvement.

Normative data for the Sergeant jump test:

Table 1. National norms for 16 to 19 year olds (Brian Mackenzie 2005).

Gender	Excellent	Above average	Average	Below average	Poor
Male	>65cm	50-65cm	40-49cm	30-39cm	<30cm
Female	>58cm	47-58cm	36-46cm	26-35cm	<26cm

Myotest

The Myotest (Myotest, Sion, Switzerland) system allows you to calculate the jump height using an accelerometer placed on the pelvis with integration calculations, allowing you to determine the sensor's vertical displacement (i.e. jump height).

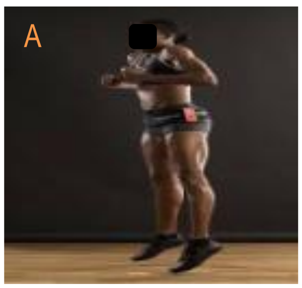

Figure 2. Saut Puissance Test (A) and Saut Detente Test (B).

Research sample

The sample of the study consisted of 33 footballers from two different teams MCM and WRM (2017/2018):

- WRM: 18 players (less than 17 years old).
- MCM: 15 players (less than 17 years old).

Statistical analysis

In this study, we have used the program of statistical packages of social sciences (SPSS) for the statistical treatment in addition to these statistical tools.

Coefficient of variation –mean – standard variation- standard deviation- t-test.

RESULTS

Table 1. Descriptive analysis results of Saut Puissance Test (WRM).

Statistical variables	Mean	Standard deviation	Skewness	Kurtosis
Height	31.61	6.87	2.76	9.91
Capacity	46.41	7.31	0.520	0.477
Maximum capacity	50.28	6.68	0.587	0.335
Force	25.54	3.88	0.010	0.981
Velocity	239.44	16.88	-0.368	1.126

From the presented table, we can conclude that the values of descriptive statistical variable give the researcher a clear indication about all the values related to central tendency and dispersion scales. We can also conclude that the descriptive statistics are very important in the statistical test. The values of skewness were within their specified range (±3), as a result, we can say that the data falls within the normal distribution curve. On the other hand, the arithmetic mean of each of the statistical variables (height, capacity, force, velocity,) has reached (31.61)(46.41)(50.28)(25.54)(239.44). All these data with the values of standard deviation form together the main unit to do the following tests to know all the relations and differences for the variables.

Table 2. Descriptive analysis results of Saut Puissance Test (MCM).

Statistical variables	Mean	Standard deviation	Skewness	Kurtosis
Height	29.94	5.32	1.042	1.915
Capacity	43.91	7.35	0.322	-0.951
Maximum capacity	48.33	9.64	1.013	1.193
Force	22.74	2.91	0.482	1.075
Velocity	242.53	23.002	0.536	-0.088

From the presented table, we can conclude that all the values of descriptive statistical variable give the researcher a clear indication about all the values related to central tendency and dispersion scales. We can also conclude that the descriptive statistics are very important in the statistical test. The values of skewness were within their specified range (±3), as a result, we can say that the data falls within the normal distribution curve. On the other hand, the arithmetic mean of each of the statistical variables (height, capacity, force, velocity,) has reached (29.94) (43.91) (33.48) (74.22) (53.242). All these data with the values of standard deviation form together the main unit to do the following tests to know all the relations and differences for the variables.

Table 3. Descriptive analysis results of Saut Detente Test (WRM).

Statistical variables	Mean	Standard deviation	Skewness	Kurtosis
Height	33.35	2.78	-0.459	-0.963
Capacity	49.76	17.72	0.346	2.318
Force	45.63	30.81	0.777	-1.514
Velocity	357.27	171.09	2.297	5.610

From the presented table, we can conclude that the values of descriptive statistical variable give the researcher a clear indication about all the values related to central tendency and dispersion scales. We can also conclude that the descriptive statistics are very important in the statistical test. The values of skewness were within their specified range (±3), as a result, we can say that the data falls within the normal distribution curve. On the other hand, the arithmetic mean of each of the statistical variables (height, capacity, force, velocity,) has reached (35.35) (76.49) (63.45) (27.357). All these data with the values of standard deviation form together the main unit to do the following tests to know all the relations and differences for the variables.

Table 4. Descriptive analysis results of Saut Detente Test (MCM).

Statistical variables	Mean	Standard deviation	Skewness	Kurtosis
Height	31.71	5.07	0.974	0.085
Capacity	39.76	7.13	-0.322	0.568
Force	21.83	2.16	0.599	0.046
Velocity	232.40	34.62	-0.107	1.392

From the presented table, we can conclude that the values of descriptive statistical variable give the researcher a clear indication about all the values related to central tendency and dispersion scales. We can also conclude that the descriptive statistics are very important in the statistical test. The values of skewness were within their specified range (±3), as a result, we can say that the data falls within the normal distribution curve. On the other hand, the arithmetic mean of each of the statistical variables (height, capacity, force, velocity,) has reached (31.71)(39.76)(83.21)(232.40). All these data with the values of standard deviation form together the main unit to do the following tests to know all the relations and differences for the variables.

Table 5. Results of the differences between WRM and MCM Saut Puissance Test (less than 17 years) height scale.

Statistical variables	**WRM**		**MCM**		**T-value**	**Sig.**
	Mean	Standard Deviation	Mean	Standard Deviation		
Height	31.61	6.87	29.94	5.32	0.768	.448
Significant level		Df = 31			Uncertainty ratios (95%)	
Statistical decision: There are no statistically significant differences.						

From the presented table, we notice that there are no statistically significant differences. The T-value was (0.768) and it is non-function value considering (sig) .448 greater than the level of significance .05. The results of arithmetic mean of each team did not reach the statistical or the demonstrative significance at the level of uncertainty ratios (95%). Accordingly, we confirm that there are no statistically significant differences between the two groups. Hence, we accept the null hypothesis and we reject the alternative one.

Table 6. Results of the differences between WRM and MCM Saut Puissance Test (less than 17 years) capacity scale.

Statistical variables	**WRM**		**MCM**		**T-value**	**Sig.**
	Mean	Standard Deviation	Mean	Standard Deviation		
Height	46.41	7.31	43.91	7.35	0.977	.336
Significant level		Df = 31			Uncertainty ratios (95%)	
Statistical decision: There are no statistically significant differences.						

From the presented table, we notice that there are no statistically significant differences. The T-value was (0.977) and it is non-function value considering (sig) .336 greater than the level of significance .05. The results of arithmetic mean of each team did not reach the statistical or the demonstrative significance at the level of uncertainty ratios (95%). Accordingly, we confirm that there are no statistically significant differences between the two groups. Hence, we accept the null hypothesis and we reject the alternative one.

Table 7. Results of the differences between WRM and MCM Saut Puissance Test (less than 17 years) maximum capacity scale.

Statistical variables	**WRM**		**MCM**		**T-value**	**Sig.**
	Mean	Standard deviation	Mean	Standard deviation		
Height	50.28	6.68	48.33	9.64	0.684	.499
Significant level		Df = 31			Uncertainty ratios (95%)	
Statistical decision: There are no statistically significant differences.						

From the presented table, we notice that there are no statistically significant differences. The T-value was (0.684) and it is non-function value considering (sig) .499 greater than the level of significance .05. The results of arithmetic mean of each team did not reach the statistical or the demonstrative significance at the level of uncertainty ratios (95%). Accordingly, we confirm that there are no statistically significant differences between the two groups. Hence, we accept the null hypothesis and we reject the alternative one.

Table 8. Results of the differences between WRM and MCM Saut Puissance Test (less than 17 years) force scale.

Statistical variables	**WRM**		**MCM**		**T-value**	**Sig.**
	Mean	Standard deviation	Mean	Standard deviation		
Height	25.54	3.88	22.74	2.91	2.304	.028
Significant level	Df = 31				Uncertainty ratios (95%)	
Statistical decision: There are statistically significant differences.						

From the presented table, we notice that there are no statistically significant differences. The T-value was (0.444) and it is non-function value considering (sig) .660 greater than the level of significance .05. The results of arithmetic mean of each team did not reach the statistical or the demonstrative significance at the level of uncertainty ratios (95%). Accordingly, we confirm that there are no statistically significant differences between the two groups. Hence, we accept the alternative hypothesis and we reject the null one.

Table 9. Results of the differences between WRM and MCM Saut Puissance Test (less than 17 years) velocity scale.

Statistical variables	**WRM**		**MCM**		**T-value**	**Sig.**
	Mean	Standard deviation	Mean	Standard deviation		
Height	239.44	16.88	242.53	23.002	-0.444	.660
Significant level	Df = 31				Uncertainty ratios (95%)	
Statistical decision: There are no statistically significant differences.						

From the presented table, we notice that there are no statistically significant differences. The T-value was (2.304) and it is non-function value considering (sig) .028 greater than the level of significance .05. The results of arithmetic mean of each team did not reach the statistical or the demonstrative significance at the level of uncertainty ratios (95%). Accordingly, we confirm that there are no statistically significant differences between the two groups. Hence, we accept the null hypothesis and we reject the alternative one.

Table 10. Coefficients of variation in physical tests for MCM

Statistical variables	**Arithmetic mean**	**Standard**	**Standard Deviation**	**Coefficient of variation value**
Explosive force test of lower extremities (Saut Puissance)	31.611	1.620	6.874	16.74
Explosive force test of lower extremities (Saut Detente)	35.350	0.655	2.782	7.86
Sargent Test	42.666	1.806	7.665	17.96

It is noticed from the above table that the value of the coefficient of variation for the explosive force test of lower extremities using Myotest reached (16.74) (7.86), and the value of the coefficient of variation for the same test using Sargent test reached (17.96). As a result, we can say that the dispersion of Sargent test sample is greater when using the Myotest device. Indeed, the values of the coefficients of variation for both variables indicate that the accuracy ratios are the best when using Myotest. The obtained values indicate also the validity and the accuracy of these tests using the Myotest device in terms of dispersion values being low due to the high level of arithmetic accuracy. Therefore, the researcher believes that the validity and the effectiveness of using the Myotest device is better to reduce the simulation of uncertainty ratios, as well as to determine the levels and standards scores for each test in a scientifically correct manner. In addition to its demonstrative power.

Table 11. Coefficients of variation in physical tests for MCM.

Statistical variables	Arithmetic mean	Standard	Standard Deviation	Coefficient of variation value
Explosive force test of lower extremities (Saut Puissance)	29.940	1.375	5.328	17.79
Explosive force test of lower extremities (Saut Detente)	31.713	1.311	5.079	16.01
Sargent Test	43.366	2.101	8.140	18.77

It is noticed from the above table that the value of the coefficient of variation for the explosive force test of lower extremities using Myotest reached (17.79) (16.01), and the value of the coefficient of variation for the same test using Sargent test reached (18.77). As a result, we can say that the dispersion of Sargent test sample is greater when using the Myotest device. Indeed, the values of the coefficients of variation for both variables indicate that the accuracy ratios are the best when using Myotest. The obtained values indicate also the validity and the accuracy of these tests using the Myotest device in terms of dispersion values being low due to the high level of arithmetic accuracy. Therefore, the researcher believes that the validity and the effectiveness of using the Myotest device is better to reduce the simulation of uncertainty ratios, as well as to determine the levels and standards scores for each test in a scientifically correct manner. In addition to its demonstrative power.

DISCUSSION

The use of Myotest device is more effective to assess the explosive force of the lower extremities of football players in terms of their coefficient of variation in comparison to the application of Sargent test. This hypothesis stems from the principle that using the Myotest device in modern technologies is better than the traditional testing method (Sargent). Myotest device provides the greatest amounts of accuracy and velocity to evaluate the elements of physical fitness. Through this study, the obtained results reveal the ability of Myotest device to evaluate the explosive force characteristics of the lower extremities in a short period with less effort and more accuracy. All that is proved by the obtained data using Myotest device to measure and evaluate lower extremities' explosive force. The Myotest device also contributes in recalling the stored information in a short period of time, which contributes to solve many problems in the training process.

Throughout the results of the tables (10.11) the value of the coefficient of variation for lower extremities' explosive force (saut puissance) and (saut détente) using the Myotest is less than the values of the same test using Sargent test. As a result, we notice that dispersion in Sargent test is greater when using Myotest. The values of the coefficient of variation for both variables also indicate that the percentages of accuracy of tests is the best when using Myotest. Moreover, these values indicate the validity of tests using Myotest in terms of its low dispersion values because of the high level of accuracy in comparison to confidence intervals that are so low. Therefore, the researchers believe that the validity and the effectiveness of using Myotest is better to reduce the percentages of confidence intervals. As well as to determine the levels of each test in a correct scientific way.

According to the study of Theodoros M. Bampouras et al (2013) Myotest accelerometric system is a valid and reliable tool for the assessment of vertical jump height Therefore, this device can be used with confidence to detect within-group changes in longitudinal assessments (e.g., to verify the effectiveness of a specific training program, to quantify possible alterations during the competitive season) and between-group differences in cross-sectional comparisons (e.g., for talent detection). Compared to the other devices for field-based jumping evaluation (photoelectric cells and contact mats),Myotest has the advantages of being extremely portable and easy to use, relatively inexpensive, and also to respect the specificity between sport activities and jumping evaluation (e.g., it can be used on sand) (Theodoros M., et al. 2013).

According to the study of Brett A. Comstock et al (2011), The Myotest instrument demonstrates a very high degree of concurrent validity along with reliability as a field-testing instrument. The relative changes to track any type of training program will be sensitive to a, 5% of treatment effect. Placement of the Myotest instrument seems to be a vital consideration when using a barbell or when rotational effects or horizontal deviation are in play (Brett et al 2011).

According to the study of N. Houel et al (2011) the Myotest Pro system can be used to evaluate Vmax of subject's centre of mass during a squat jump with acceptable accuracy (error >0.3 m.s-1) and reliability (bias <0.1 m.s-1). The Myotest Pro estimate Vtoff with a small validity (95% limit of agreement >0.8 m.s-1) and underestimate t with a significant different bias (>0.03 s). So it cannot be used to estimate Vtoff and t of subject's centre of mass. Difference between results on Vtoff and t on both devices can be explained by the hypothesis of measurements of the Myotest Pro. If the centre of mass is currently used to evaluate the squat jump, Performance the Myotest Pro sensor can only estimate the acceleration of the point where it is fixed. In contrary to some study where soft development takes into account the position of the accelerometer to estimate the centre of mass kinetics' variables (Vmax, Vtoff, t) ,the Myotest Pro system only estimates the hip motion. In conclusion, the Myotest Pro can be used only to estimate Vmax of the centre of mass during a squat jump, or Vtoff and t of the hip where it is fixed. Force plate or other sensors could be preferred to estimate kinetics variables of the centre of mass (N. Houel 2011).

AUTHOR CONTRIBUTIONS

This study was conducted by a group of researchers from the Laboratory of Science and Techniques of Physical and Sports Activities, Algiers 3 University, Algeria; composed of:

- Khodja Bacem: Linguistic correction. The use of statistical package program of social sciences SPSS. Specifying the title and the research problem of the study. The contribution to the design of physical tests. Substantial contribution to acquisition, analysis and interpretation of data. Drafting the article, and final approval of the version to be published. Preparation and presentation of the published work by members of the original research group, including review, discussion, or revision including pre- or post-publication stages. Analysis and collection of data using statistical techniques. Preparation and presentation of published work, focusing on data presentation. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work.
- Tahar Briki: Specifying the title and the research problem of the study. The contribution to the design of physical tests. Substantial contribution to acquisition, analysis and interpretation of data. Drafting the article, and final approval of the version to be published. Preparation and presentation of the published work by members of the original research group, including review, discussion, or revision including pre- or post-publication stages. Analysis and collection of data using statistical techniques. Preparation and presentation of published work, focusing on data presentation. Agreement to be

accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work.

- Ahmed Hamza Ghadbane: Specifying the title and the research problem of the study. The contribution to the design of physical tests. Substantial contribution to acquisition, analysis and interpretation of data. Drafting the article, and final approval of the version to be published. Preparation and presentation of the published work by members of the original research group, including review, discussion, or revision including pre- or post-publication stages. Analysis and collection of data using statistical techniques. Preparation and presentation of published work, focusing on data presentation. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work.

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No potential conflict of interest was reported by the authors.

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ORIGINAL ARTICLE

The university student's engagement in recreational sports activities as a means to promote mental well-being in the context of Coronavirus pandemic: An empirical study on a sample of female university students at Mohamed Boudiaf University in M'sila

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ABSTRACT

The study aimed to identify the university student's engagement in recreational sports activities as a means to promote her mental well-being in the context of the Coronavirus pandemic. For this purpose, a descriptive-analytical approach was adopted, and to achieve the study's objectives, a pre-designed questionnaire was utilized to assess the university student's engagement in recreational sports activities as a means to promote her mental well-being in the context of the COVID-19 pandemic. The questionnaire was distributed to a sample of female university students at the University of M'sila using a purposive sampling method, with a total of 31 university students participating. To address the study's questions, the data obtained from the sample individuals were processed using appropriate statistical methods, and the study's results indicated the following: Engagement in recreational sports activities by university students contributes to the promotion of their mental well-being in the context of the COVID-19 pandemic; The university student's engagement in recreational sports activities works to enhance her self-confidence in the context of the COVID-19 pandemic; The university student's engagement in recreational sports activities works to reduce her psychological stress in the context of the COVID-19 pandemic; The university student's engagement in recreational sports activities works to alleviate her anxiety in the context of the COVID-19 pandemic.
Keywords: Sport health, Recreational sports activities, Mental well-being, Coronavirus, COVID-19.

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INTRODUCTION

The coronavirus pandemic has forced a halt to the normal course of life and disrupted various activities, leading to enforced full lockdowns, closure of schools and universities, and restrictions on individual movement. This has created a genuine crisis in various aspects of life, resulting in substantial alterations in our daily experiences. As a consequence, our psychological responses to usual interactions have shifted under the immense pressure and ongoing sense of threat posed by this pandemic.

The widespread impact of this crisis on individuals' mental health has prompted many in society to turn to recreational sports activities as a means to overcome the significant psychological barrier imposed by this health crisis and to mitigate its physical, social, and psychological effects.

Considering these recreational sports activities as vital for physical, mental, and psychological well-being, sport represents a significant opportunity for enhancing individuals' mental health. The university student is considered one of the groups affected by this health crisis, in addition to the pressures of the pandemic, health, study, and daily life. She has been under these pressures for long hours, resulting in a deterioration of her mental health.

The only way out of this situation for her is to turn to engaging in recreational sports activities in specialized sports facilities. The goal is to alleviate the psychological anxiety resulting from the global health crisis, as well as to improve her physical fitness, leading to enhanced mental well-being, reduced symptoms of anxiety and depression, increased self-confidence, improved mood, and relief from psychological stress through recreational and sports-oriented entertainment. Therefore, this research paper aims to approach women's sports and to understand the role of recreational sports activities as a gateway to achieving the mental health of university students in the midst of the coronavirus pandemic crisis.

Study problem

Human societies have recently witnessed a catastrophic and serious health situation as a result of the terrifying and tremendous invasion of the coronavirus pandemic, which has brought about an unprecedented crisis that has shaken the habits and behaviours of individuals and groups, forcing them to coexist with panic and anxiety due to the worsening health crisis, terrifying and rapid spread of infection, and the increasing number of cases and casualties.

Thus, avoiding and overcoming this critical and exceptional situation has become a top priority in order to comply with the preventive health measures for this pandemic and to risk maintaining the new lifestyle. The COVID-19 pandemic has created a situation with additional harsh repercussions on women due to the grim picture of the epidemic and the health threats it poses. Women are beings who experience numerous psychological frustrations, easily succumb to pressures, obstacles, and risks, and cannot bear high levels of stress, anxiety, panic, maladaptation, and disorders. This unfamiliar reality, characterized by closures, sieges, and lifestyle changes imposed by the health threats posed by the virus and its rapid spread, as well as the significant number of casualties, has had negative effects on the mental health of wide segments of educational communities.

Among these segments are university female students who face many challenges in their local environments due to the strict health measures resulting from the pandemic, in addition to the emerging psychological, health, and social challenges in the face of the COVID-19 pandemic.

The COVID-19 pandemic has significantly led to a decline in mental health and exacerbated psychological suffering for a wide range of female university students. These students have been characterized by fear, anxiety, depression, and continuous psychological pressure as a result of the prolonged presence and rapid spread of the virus, which has threatened the lives of individuals and communities.

To address this situation and raise awareness among university students about the need to overcome the various effects of this health crisis, as well as to make them aware of the contribution of leisure sports and physical activities in improving their physical and mental health, a wide range of female university students have once again turned to engaging in leisure sports activities in specialized sports facilities. This is in order to cope and adapt to this critical health condition, as well as to enhance their mental health and reduce the various psychological disorders imposed by the situation of closure and quarantine. Therefore, this topic requires further research to reach appropriate solutions to the issue of studying while promoting the mental health of individuals in educational communities amidst the COVID-19 pandemic. This study aims to shed light on the practice of female university students engaging in leisure sports activities as an approach to achieving their mental health during the COVID-19 pandemic. It aims to answer the following research question:

Main research question
Does the participation of female university students in leisure sports activities contribute to enhancing their mental health amidst the COVID-19 pandemic?

Subsidiary research questions
- Does the participation of female university students in leisure sports activities enhance their self-confidence amidst the COVID-19 pandemic?
- Does the participation of female university students in leisure sports activities alleviate their psychological stress during the COVID-19 pandemic?
- Does the participation of female university students in leisure sports activities reduce the severity of their anxiety amidst the COVID-19 pandemic?

Study objectives
The study objectives are as follows:
1. To identify the practice of female university students engaging in leisure sports activities as a means to achieve their mental health amidst the COVID-19 pandemic.
2. To determine if the participation of female university students in leisure sports activities enhances their self-confidence during the COVID-19 pandemic.
3. To investigate if the participation of female university students in leisure sports activities alleviates their psychological stress amidst the COVID-19 pandemic.
4. To examine if the participation of female university students in leisure sports activities reduces the severity of their anxiety during the COVID-19 pandemic.
5. To identify the psychological challenges faced by female university students amidst the COVID-19 pandemic.
6. To contribute to the theoretical literature on the subject by incorporating the current study's findings.

The significance of the study
This study aims to elucidate the importance of female university students engaging in leisure sports activities as a means to achieve their mental health amidst the critical phase characterized by the rapid spread of the COVID-19 pandemic.

It also highlights the importance of leisure sports activities and the necessity for female university students to practice them, given the numerous positive health and psychological effects derived from such engagement. These effects include enhancing physical fitness, providing entertainment and relaxation, improving mood, boosting self-confidence, alleviating various psychological pressures, reducing symptoms of stress and anxiety, and effectively overcoming and transcending psychological disorders to reach a state of mental and physical well-being.

The importance of the current study can be summarized as follows:

- It lies in the nature of the subject it addressed (leisure sports activities and mental health) for female university students in the context of the COVID-19 pandemic.
- It reveals the negative effects of the COVID-19 pandemic on educational communities.
- This study assists in obtaining information about enhancing the mental health of female university students amidst the COVID-19 pandemic.

Study limitations

The study was delimited by the following aspects:

Objective limitations

The objective limitations of the study focused on identifying the role of female university students' engagement in leisure sports activities as a means to achieve mental health amidst the COVID-19 pandemic.

Human limitations

The human limitations of the study were confined to a sample of 31 female university students engaging in leisure sports activities.

Spatial limitations

The spatial limitations of the study were defined by the University of Mohamed Boudiaf in M'sila.

Temporal limitations

The study was delimited by the period extending from April 16th to April 31st, 2021.

Procedural definition of study concepts and terms

Leisure sports activities: These are the various games and sports practiced by female university students in specialized sports facilities.

Mental health

It is measured through the responses of the study sample to questions related to quarantine, and then the sample's responses to the dimensions of the mental health questionnaire (the role of leisure sports activities in enhancing self-confidence, the role of leisure sports activities in reducing psychological pressure, the role of leisure sports activities in reducing anxiety) estimated to be 21 items.

COVID-19 Pandemic

The COVID-19 pandemic, which has spread since the end of 2019 and throughout 2020, continues to spread into the new year 2021. It has spread throughout the world, leading to quarantine, full and partial closures of countries and cities, cancellation of mobility and travel, and the closure of schools and universities. In 2021, partial resumptions of studies and social and economic activities have occurred under strict health measures.

Previous studies

The nature of this study required the researcher to review previous studies related to the subject of the current study and to utilize them in discussing the study's results. These studies have been classified according to their indicators and their chronological order as follows:

Masouda (2019) conducted a study that aimed to uncover the role of physical and aerobic exercise and its impact on the psychological health of practicing women. The study concluded that physical aerobic activity plays a significant role in achieving psychological health in women, as it reduces psychological pressure, enhances self-confidence, and alleviates anxiety.

Similarly, Abdessalam and Lamine (2018) conducted a study aimed at revealing the role played by physical education and sports in reducing the level of anxiety among secondary school students. The study found that physical education and sports significantly contribute to alleviating anxiety among secondary school students.

Naima (2018) conducted a study aimed at uncovering the relationship between sports culture and women's attitudes towards practicing aerobic exercise. Among the most important results obtained: The women's attitude was positive towards sports and practicing aerobic exercise.

Bofrida 2016 conducted a study aimed at clarifying the role of recreational physical and sports activity and its impact on reducing psychological pressures among adolescent schoolgirls in the secondary stage (17-18 years old). The study concluded the following results: Physical aerobic activity plays an effective role in reducing psychological pressures among third-year secondary school female students.

The benefits of previous studies

Through reviewing previous studies, it is evident that they focus on the topic of sports activities and individuals' mental health. The current study follows the same path, but it has chosen an important category of educational communities in universities to shed light on the role of engaging in recreational sports activities as an approach to achieving the psychological well-being of female university students during the COVID-19 pandemic. This study aims to clarify the reality of female university students' engagement in sports activities and to understand the awareness of this group regarding the importance of these activities during this critical stage, which imposed a state of closure, quarantine, and the implementation of health measures due to this new reality and the necessity of living with it.

The current study has benefited from previous research in terms of both the adopted methodologies and the tools used, as well as the results obtained. This methodological harmony of previous studies has enriched the current study in form, content, and methodology.

The theoretical aspect of the study

Firstly, recreational sports activities

Sports are considered one of the important human activities. Almost every society, regardless of its level of advancement or backwardness, includes some form of sports activity.

Throughout different ages and civilizations, humans have recognized the significance of sports. While various civilizations have had different approaches to sports, some emphasized sports for military purposes, whether defensive or expansionist.

Others engaged in sports as a way to pass the time and for recreation, while in other civilizations, sports were utilized as an educational method. Ancient educational thinkers recognized the values embodied in sports as well as their powerful potential in shaping and nurturing balanced social personalities, not to mention the health benefits associated with physical activity and sports training since ancient times. It is a concept supported by the results of scientific research related to the functional and health effects at the biological level of humans (Anwar El Khawly, 1996, p. 5).

The growing interest in sports has become issues and problems with a fundamentally social nature, as the real requirements of people derive from the intricacies of social and economic circumstances, especially in the wake of the changes brought about by social change trends, cultural transfer factors, and tremendous technological advances and the development of information transfer methods (Anwar El Khawly, 1996, p.7).

Recreational physical activity
It refers to those games or sports that are practiced in leisure time and free from intense competition, serving as a means of occupying leisure time (Bouabdellah & Boutalbi, 2014, p. 14).

The psychological approach to recreational sports activities
Recreational sports activities have important psychological aspects, including:

- Providing opportunities for experiencing new experiences and feeling of comfort and self-worth.
- Offering opportunities for building self-confidence, eliminating shyness, promoting happiness and achieving success.
- Developing qualities such as integrity, compassion, emotional control, and authenticity.
- Providing the greatest opportunities to eliminate aggressive tendencies in socially acceptable conditions.
- Enhancing mental health and emotional maturity.
- Fulfilling inclinations and motivations related to play and hobbies, contributing to the individual's psychological satisfaction from participating in recreational physical activity.

The individual's emotional health development and psychological balance are enhanced through engaging in recreational physical activity, which contributes to relieving or reducing psychological stress, anxiety, and levels of depression (Bouabdellah & Boutalbi, 2014, pp. 15-16).

Sports and women
Women need sports just as much as men do, as their bodies are composed of muscles, joints, ligaments, heart, and organs that are all designed to work and move. With women's participation in the workforce and education, it is imperative for them to maintain their weight, figure, and health.

Recent research has shown an increased susceptibility of women to heart and artery diseases (especially during menopause) due to the modern lifestyle they lead, where modern conveniences at home allow them to work without exerting any physical effort as they did in the past. Therefore, women without exercise become vulnerable to illness, flabbiness, and excessive obesity (Farouk Abdel Wahab, 1995, p.71). "*In our Arab society, women undergo changes after marriage, often attributed to weight gain. However, these are all superficial excuses. The main reason is excessive eating, especially during pregnancy, combined with lack of physical activity or exercise*". This leads to various health issues, the most significant being obesity, which often leads to psychological problems. This, in turn, may result in social problems, the most serious of which is marital breakdown or dissolution.

"*The solution is simple women should take care to engage in physical exercise before, during, and after pregnancy, strengthening their bodies and maintaining family cohesion, the love of their husband, and the respect of all*" (Farouk Abdel Wahab, 1995, p.71). "*There are certainly physiological differences between men and women. The blood volume in women is lower than that in men of the same size and age, as is their respiratory capacity and oxygen consumption*". This is due to the fact that women have less muscle mass. Additionally, women are typically shorter than men of the same age. Therefore, although their blood volume and oxygen capacity are lower, they are proportionate to their body size and muscle mass. Consequently, their ability to engage in sports is not affected by these physiological differences, and training can reduce or minimize these discrepancies (Farouk Abdel Wahab, 1995,p.74).

Home-based physical activities

There are plenty of diverse physical activities and exercises that can be done at home without the need for equipment or large spaces. For instance, walking from one room to another for a few minutes every half an hour, as well as using the stairs for ascending and descending, and performing bodyweight exercises such as arm exercises for ten consecutive repetitions within three varied sets with one to two minutes of rest between each set. Additionally, aerobic dancing can also be practiced, and one can utilize the television to follow fitness programs and perform the exercises simultaneously. Furthermore, one can search online for physical activities and apply them, or even contact friends or fitness trainers through smartphones. To open video calls for shared sports activities is a way to cultivate and strengthen social relationships while engaging in physical activity (Source: http://www.awraqthaqafya.com/920/).

Sports and health

Sports serve as a form of physical therapy that is currently encouraged by medical professionals. Moreover, sports play a crucial role in preventing various diseases before they require treatment. The most important diseases that sports help to prevent or treat include:

Psychological disorders

Such as depression, anxiety, and stress are prevalent among modern individuals due to the lifestyle they lead, which often results in constant psychological turmoil. This is attributed to sedentary behaviour, social isolation, and the fear or concern about success or failure in the future. Consequently, individuals often experience anxiety and stress, which may have started from early childhood.

Stress and anxiety are accompanied by excessive hormone secretion, leading to increased tension, rapid heart rate, and a lack of relaxation. Such symptoms can be alleviated by engaging in physical activity for a few minutes each day, which can help individuals to alleviate the effects of hormones, feel confident and at ease, and overcome feelings of depression, stress, anxiety, and mental fatigue.

Cardiovascular diseases

Exercise is an important method for both preventing and treating heart diseases, including high blood pressure, atherosclerosis, and coronary artery disease, which are increasingly prevalent among young people. Psychological stress, anxiety, and other pressures can contribute to elevated blood pressure and heart rate. This can lead to an increase in cholesterol and triglycerides in the blood, making individuals more susceptible to cardiovascular diseases and at risk of experiencing a stroke, heart attack, or coronary thrombosis. Engaging in physical activity helps to improve the elasticity, flexibility, and dilation of blood vessels, thereby regulating blood pressure, enhancing circulation, and significantly reducing the risk of cardiovascular diseases. (Farouk Abdul Wahab, 1995, pp. 99-100).

Back pain
Prolonged sitting at a desk, in a car, and at home puts significant pressure on the muscles of the back and pelvis, leading to continuous pressure on the intervertebral discs. This can result in back pain and disc herniation, affecting posture and movement, especially when standing and walking. Therefore, regular and proper physical activity and exercise protect against these symptoms.

Postural deformities
Exercise is one of the most important methods for preventing and treating postural deformities, especially in young ages. Therefore, there is a strong focus on posture correction exercises for children and adolescents to prevent spinal curvature, foot deformities, knee friction, and back curvature, among other postural deformities.

Diabetes
Exercise is used as an effective method in treating non-hereditary diabetes primarily. Furthermore, exercise is used as a preventive measure for both hereditary and non-hereditary diabetes, along with the appropriate dietary program, of course.

Gout
Exercise helps in reducing the elevation of uric acid that causes this disease, whether due to the consumption of red meat or legumes. Therefore, those suffering from this disease resort to exercising to alleviate its excruciating pain.

Rheumatism
Engaging in physical activity helps to increase body temperature, which often aids in alleviating rheumatism pain, especially in its early stages.

Other diseases
Many diseases can be prevented and treated through exercise, which also helps in alleviating conditions such as headaches, general weakness, and other illnesses. (Farouk Abdul Wahab, 1995, p.102).

Secondly, Mental Health
The Concept of Mental Health
There have been numerous attempts to define mental health. The differences in these attempts are attributed to the diversity of perspectives and schools of thought. Among these definitions, researcher Hameed Abdul Salam Zahran (1977, p.9) defines it as the scientific study of mental health, the process of psychological adjustment, its achievements, hindrances, psychological problems, disorders, and diseases.

Mental health has two essential dimensions: theoretical scientific dimension that deals with the patient's personality in terms of causes, symptoms, adjustment, dissemination of knowledge, motivations, needs, study of causes, treatment, and prevention. The second dimension is the applied scientific dimension, which requires the use of various methods and techniques for examination, diagnosis, treatment, and preventive programs.

Abdulkhaliq (1991) defines it as a relatively permanent complex emotional-mental state in which everything is going well, feeling happy with oneself and others, feeling content and secure, mental safety, embracing life with a sense of activity and strength. This state is characterized by a high degree of psychological and social harmony, with satisfactory and fulfilling social relationships.

On the other hand, Alaa Al-Din Kafafi (1997, p.81) defines mental health as a state of balance and integration of the individual's psychological functions that lead them to adopt a way that enables them to accept themselves and be accepted by society, resulting in a sense of satisfaction and sufficiency.

As for Adeeb Al-Khaldi (2002, p.23), he defines it as a relatively permanent state in which the individual is psychologically, emotionally, and socially harmonious (with oneself and with the environment), experiencing happiness within oneself and with others, capable of self-realization, utilizing their potential to the fullest, able to cope with life's demands. Their personality is well-integrated, their behaviour is normal, and they possess good manners, enabling them to live in safety and peace. From the definitions of mental health provided by psychologists, it can be inferred that it is a psychological state involving feelings of satisfaction, happiness, and contentment. It also entails psychological, emotional, and social harmony, as well as adaptation of the individual to oneself, others, their community, and environment. It can be defined as the level of psychological well-being and the psychological state of a person who possesses a good emotional and behavioural level.

Women's mental health

In light of the current global changes, particularly the COVID-19 pandemic, women require special healthcare attention due to the differences in their physical and psychological makeup, in addition to the constant pressures they face at home, in public, in their studies, and in the workplace.

Women undergo numerous biological changes that require special care and attention due to factors such as age, lifestyle, dietary habits, physical activity, and hormonal fluctuations. Additionally, psychological factors are among the most important factors linked to a woman's life, safety, and mental resilience. Society plays a significant role in promoting women's mental health, transitioning from creating healthy conditions that support mental well-being to emphasizing the importance of women's self-care through communication with others and allocating time for engaging in activities and hobbies. This role extends to promoting health education, including training women to control and manage sources of psychological stress, as well as addressing and mitigating them, in addition to attending to all of women's psychological needs.

METHODOLOGY

The descriptive-analytical method was adopted as a method that describes and interprets reality. This was achieved through a review of theoretical literature on recreational sports activities and the mental health of female college students. The field study was then conducted, and results were obtained to contribute to enriching the topic of mental health and recreational sports activities for female college students.

Study population and sample

The study population included female college students at Mohamed Boudiaf University in El M'Sila who engage in recreational sports activities in sports halls and leisure centres. The study sample consisted of 31 female college students who engage in recreational and physical sports activities. Participants were purposefully selected.

Data collection tool

By referring to studies related to both mental health and sports activities, and through relevant previous research, a pre-prepared questionnaire developed by the researcher Masouda Ben Othman (2019) was adopted for its suitability in achieving the objectives of the current study and for collecting data from the study sample.

Tool description

The study questionnaire consists of two main sections:

- The first section: It includes questions related to mental health.
- The second section: This section of the questionnaire consists of 21 items focusing on the mental health of female college students, distributed across three dimensions as follows:
    - Dimension 1: The role of recreational sports activities in boosting self-confidence (07 items).
    - Dimension 2: The role of recreational sports activities in reducing psychological pressure (07 items).
    - Dimension 3: The role of recreational sports activities in reducing anxiety (07 items).

Survey study

The researcher conducted a pilot survey study on a preliminary sample of (18) individuals in order to verify the psychometric properties of the study tool, ensure its suitability for the final application, and achieve the study's objectives.

Psychometric properties of the study tool

Content validity

The researcher verified the content validity of the tool through established procedures. The tool was presented to a group of expert professors from the psychology department at the University of M'Sila for item validation and to ensure its suitability for the current study. This was done to ensure that the tool measures what it was designed for. The final output of the tool achieved consensus among the expert professors, and thus, the study tool was adopted to achieve the study's objectives and to collect data from the study sample.

Reliability

To verify the reliability of the study tool, the split-half method was utilized and applied to a pilot sample of (18) female college students practicing sports in sports facilities. After obtaining the results, the questionnaire items were divided into odd and even items, and the reliability was calculated. The Pearson correlation coefficient between the odd and even items was found to be (0.71), which is an acceptable value in descriptive research and studies. This proves that the tool possesses high reliability, and its measurement can be trusted. The practice of female college students engaging in recreational sports activities as a means to achieve mental health during the COVID-19 pandemic is supported by this.

Statistical methods

Several appropriate statistical methods were used to process the data obtained from the study sample, including the Pearson correlation coefficient, frequencies, and percentages.

RESULTS

Presentation, analysis, and interpretation of results in light of quarantine:

Table 1. Did you stop practicing sports in sports facilities and clubs during the quarantine period?

Yes	No	Total
24	7	31
77.42%	22.58%	100%

It is noted that 77.42% of the study sample continued to practice sports during the lifting of the quarantine, while 22.58% discontinued their activity. This can be attributed to various reasons including getting used to the quarantine, unawareness of the reopening schedule for sports facilities, fear of getting infected, and the fact that college students are accustomed to practicing sports activities at home during the quarantine period.

Table 2. Have you considered practicing sports at home during the quarantine period?

Yes	No	Total
23	8	31
74.19%	25.81%	100%

It is noted that 74.19% considered practicing sports at home and did not discontinue it, as recreational sports activities are important for their health. Meanwhile, 25.81% did not consider home sports activities, primarily due to being preoccupied with news about the coronavirus pandemic, quarantine, and the increasing number of infections and deaths.

Table 3. What type of sports did you engage in at home during the quarantine?

Number	Type of Sport	Repetition
01	Home – based Zumba exercises	5
02	Home aerobics exercises	3
03	Jumping rope	9
04	Exercise using devices	0
05	Home walking exercise	9
06	Free exercise	5
	Total	31

It is noteworthy that skipping rope and home walking were the most popular activities, as these sports do not require equipment, and most college students do not have sports equipment at home due to their financial inability and the low economic status of their families. Zumba, home aerobics, and free sports activities ranked next, as most college students who engage in these recreational sports activities follow registered sessions on YouTube, and these activities have recently gained great popularity among female groups.

Table 4. Do you have sports equipment at home?

Yes	No	Total
01	30	31
3.23%	96.77%	100%

It is observed that 96.77% of college students who do not have sports equipment at home still engage in sports, while 3.23% own sports equipment and engage in sports. This is because college students are accustomed to exercising in sports halls in university residences.

Table 5. Has a doctor previously advised you to exercise for your health?

Yes	No	Total
5	26	31
16.13%	83.87%	100%

It is noted that 16.13% of them have been previously advised by a doctor to exercise for their health, while the other half exercise based on their own willingness, as a result of their health awareness, and also due to the social tradition of attending the sports halls available in the university residence.

Table 6. Do you exercise for physical health purposes?

Yes	No	Total
18	13	31
58.06%	41.94%	100%

It is observed that 58.06% of female college students exercise for the purpose of maintaining their physical health, attributed to their awareness of the importance of exercise in enhancing their mental and physical health.

Table 7. Do you exercise for the purpose of maintaining your physique and appearance?

Yes	No	Total
16	15	31
51.61%	48.39%	100%

From the figure, it is noticeable that 51.61% of female college students continue to engage in physical activities to maintain their body shapes, fearing obesity, fat accumulation, and lack of agility and agility, and to achieve a suitable appearance both personally and socially.

Presentation, analysis, and interpretation of the results in light of the study's questions

Does the engagement of female college students in recreational physical activities contribute to enhancing their mental health in the context of the COVID-19 pandemic?

To answer the main question, the percentage dimensions of the study tool were calculated, and the following results were obtained:

Table 8. Percentage dimensions of the study tool according to the responses of female college students.

Number	Axes	Always (%)	Sometimes (%)	Never (%)
01	Dimension 1: The role of recreational physical activities in enhancing self-confidence	75.58	13.82	10.60
02	Dimension 2: The role of recreational physical activities in reducing psychological stress	88.02	06.45	05.53
03	Dimension 3: The role of recreational physical activities in reducing anxiety	88.48	05.53	05.99
	Total percentage for all dimensions	84.02	08.60	07.37

Table 8 shows that 84.02% of female college students believe that recreational physical activities contribute to enhancing their mental health in the context of the COVID-19 pandemic. On the other hand, 8.60% of female college students are hesitant, while 7.37% do not believe that engaging in recreational physical activities plays a role in enhancing their mental health.

The third dimension ranked first at 88.48%, while the second dimension ranked second at 88.02%, and the first dimension ranked last at 75.58%. The results of the current study are consistent with those of Masouda (2019) and Abdel Salam and Lameen (2018) studies. The study by Boufrida (2016) demonstrates the significant role of physical sports activities in enhancing individual mental health, as engaging in such activities reduces psychological pressure, boosts self-confidence, and alleviates anxiety.

Does engaging in recreational physical activities enhance the self-confidence of female university students in the context of the COVID-19 pandemic?
To answer the first sub-question, the frequencies and percentages of the items in the first dimension were calculated. The following results were obtained:

Table 9. Frequencies and percentages of the items in the first dimension (Role of recreational physical activities in enhancing self-confidence).

Number	**Item**	**Always**		**Sometimes**		**Never**	
		Frequency	%	Frequency	%	Frequency	%
01	I organize and coordinate my tasks while engaging in recreational physical activities	19	61.29	5	16.13	7	22.58
02	I try to benefit from the experiences of others while engaging in recreational physical activities	17	54.84	8	25.81	6	19.35
03	I have the ability to overcome the problems I encounter while engaging in recreational physical activities	23	74.19	4	12.90	4	12.90
04	I seek to develop self-confidence during engaging in recreational physical activities	29	93.55	1	3.23	1	3.23
05	I have the ability to convey my thoughts to others while engaging in recreational physical activities	20	64.52	8	25.81	3	9.68
06	I feel greater mental security while engaging in recreational physical activities	27	87.10	3	9.68	1	3.23
07	When I trust myself during recreational sports activities, I make fewer daily mistakes.	29	93.55	1	3.23	1	3.23
Dimension 1: The Role of Recreational Sports Activities in Boosting Self-Confidence		**164**	**75.58**	**30**	**13.82**	**23**	**10.60**

Based on Table 9, it is evident that an average of (75.58%) of female university students enhance their self-confidence through engaging in recreational physical activities, while (10.60%) of female university students do not enhance their self-confidence through engaging in recreational physical activities. Additionally, (13.82%) of female university students do not show any aspect of self-confidence enhancement. As for the frequency of items, item four and item seven ("*I seek to develop self-confidence during engaging in recreational physical activities*" and "*When I trust myself while engaging in recreational physical activities, my daily mistakes decrease*") obtained the highest frequencies, amounting to (29). This indicates that engaging in recreational physical activities by female university students increases their self-confidence and enables them to resist the negative psychological effects produced by the COVID-19 pandemic, such as panic, depression, anxiety, and psychological pressure. The results of the current study are consistent with the findings of a study by Masouda (2019) that physical sports activity plays a significant role in enhancing self-confidence.

Does the engagement of female university students in recreational physical activities alleviate their psychological pressure in the context of the COVID-19 pandemic?

To answer the second sub-question, the frequencies and percentages of the second dimension were calculated, and the following results were obtained:

Table 10: Frequencies and percentages of items in the second dimension (The role of recreational physical activities in alleviating psychological pressure).

Number	Item	Always		Sometimes		Never	
		Frequency	%	Frequency	%	Frequency	%
08	Practicing recreational physical activities makes me feel calm and at ease	19	61.29	1	3.23	1	3.23
09	Engaging in recreational physical activities reduces my emotional reactions	17	54.84	2	6.45	1	3.23
10	Recreational physical activities help me achieve emotional balance, such as feeling happy	23	74.19	1	3.23	1	3.23
11	Engaging in recreational physical activities helps me to vent my emotions	26	83.87	2	6.45	3	9.68
12	I feel psychological freedom when practicing recreational physical activities	26	83.87	4	12.90	1	3.23
13	Engaging in recreational physical activities allows me to develop social relationships with others	24	77.42	3	9.68	4	12.90
14	Recreational sports activities help me to reduce stress.	29	93.55	1	3.23	1	3.23
Dimension 2:The role of recreational sports activities in alleviating psychological pressure		**164**	**191**	**14**	**13.82**	**12**	**10.60**

According to Table 10, it is evident that 88.02% of female university students agree that recreational physical activities contribute to alleviating their psychological pressure. On the other hand, 6.45% of them are hesitant in their responses, possibly unsure about feeling relief from psychological pressure. Meanwhile, 5.53% of the students did not provide any response regarding the alleviation of psychological pressure.

In terms of item frequencies, all items received high frequencies from the sample respondents, indicating their awareness of the extent to which engaging in recreational physical activities can contribute to reducing emotional reactions, achieving emotional balance, feeling calm and at ease, experiencing happiness, and reducing the severity of psychological tension to avoid the psychological effects of the COVID-19 pandemic.

The results of the current study align with those of a study by Masoud (2019) indicating that physical exercise plays a significant role in achieving mental health and reducing psychological pressure. Similarly, they also correspond with the findings of Bofreda's study (2016) in that recreational physical activities play an effective role in reducing psychological pressures.

Does engaging in recreational physical activities alleviate the level of anxiety for female university students in the midst of the COVID-19 pandemic?
To address the third sub-question, frequencies and percentages for the items of the third dimension were calculated, yielding the following results:

Table 11: Frequencies and percentages for the items of the third dimension (The role of recreational physical activities in reducing the severity of anxiety).

Number	Item	Always		Sometimes		Never	
		Frequency	%	Frequency	%	Frequency	%
15	I stay calm during my engagement in recreational physical activities	25	80.65	4	12,90	2	6.45
16	I feel at ease when engaging in recreational physical activities	27	87.10	2	6,45	2	6.45
17	Recreational physical activities help me control my emotions and get rid of anger	29	93.55	1	3,23	1	3.23
18	I forget all my academic and personal problems when engaging in recreational physical activities	26	83.87	2	6,45	3	9.68
19	I find myself psychologically comfortable after engaging in recreational physical activities	29	93.55	1	3,23	1	3.23
20	Engaging in recreational physical activities helps me prepare and get ready for my other tasks	28	90.32	1	3,23	2	6.45
21	Recreational sports activities contribute to reducing fear.	28	90.32	1	3,23	2	6.45
Dimension 3:The role of Recreational Sports Activities in Reducing Anxiety Severity.		**192**	**192**	**88.48**	**12**	**5.53**	**5.99**

Based on Table 11, it is evident that 88.48% of female university students agree that engaging in recreational physical activities contributes to reducing the severity of psychological anxiety, while 5.99% did not support this feeling.

The majority of items received the highest frequency of acceptance, confirming that the recreational physical activity practiced by female university students helps in controlling nerves, getting rid of anger, and maintaining composure. Recreational physical activities serve as the only outlet for female university students, working to mitigate the effects of the COVID-19 pandemic lockdown.

The results of the current study align with those of Masouda's study (2019) in emphasizing the significant role of physical exercise in achieving mental health and reducing anxiety. Additionally, these findings are consistent with the results of studies by Abdel Salam and Lameen (2018), indicating that physical activity significantly contributes to reducing the severity of anxiety.

CONCLUSIONS

The study results indicated the following:

- Engaging in recreational physical activities by female university students contributes to achieving their psychological well-being amidst the COVID-19 pandemic.
- Engaging in recreational physical activities by female university students works to enhance their self-confidence amidst the COVID-19 pandemic.
- Engaging in recreational physical activities by female university students helps to alleviate their psychological stress amidst the COVID-19 pandemic.
- Engaging in recreational physical activities by female university students contributes to reducing the severity of their anxiety amidst the spread of the COVID-19 crisis.

From the results of the current study, it is evident that female university students engaging in recreational physical activities have a positive understanding of the concept of health culture amidst the various effects of the COVID-19 crisis. They agree that their participation in recreational physical activities works to strengthen their psychological well-being during this pandemic, and that regular practice contributes significantly to overcoming this crisis mentally and physically.

Suggestions

Conduct studies focusing on the physical and mental health of female populations in educational communities. Conduct studies focusing on recreational physical activities for females in educational communities.

AUTHOR CONTRIBUTIONS

This work was collective, starting with the theoretical background, and everyone participated in building the measurement tool through its arbitration, distribution, and analysis, and reaching the final results and recommendations.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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SUSTAINABILITY & SPORTS SCIENCE JOURNAL

ORIGINAL ARTICLE

Activity of quadriceps muscles at different trunk tilt angles while squatting

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ABSTRACT

This study aimed to clarify the relationship between different trunk inclination angles and knee joint positions while squatting and the activity of the vastus medialis obliquus (VMO). The participants were 24 healthy young males and females. The task was performed in the squatting position with the knee joint in 60° flexion. Group F (knee forward group) allowed the apex of the knee to move over the toes in the forward direction, and group B (knee backward group) allowed it to be aligned. Furthermore, group F was set to 0° forward tilt (F0), 20° forward tilt (F20), and 40° forward tilt (F40) of the trunk, whereas group B was set to 20° forward tilt (B20) and 40° forward tilt (B40). Surface electromyography (sEMG) was used to detect action potentials from the VMO, vastus medialis longus (VML), and rectus femoris (RF). sEMG analysis showed that the vertical trunk position was significantly higher than the anterior trunk position in all muscles ($p < .05$). F0 had the smallest displacement of the anterior-posterior centre of pressure. F0 with knee flexion of around 60° and body supported by both upper limbs is a suitable squatting limb for quadriceps training, particularly in the VMO.
Keywords: Sport health, Vastus medialis obliquus muscle, Surface electromyography, Anterior-posterior centre of pressure, Muscle atrophy.

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INTRODUCTION

To achieve a sustainable society, it is necessary to address the various challenges of an ageing society. The prevention and treatment of musculoskeletal diseases and maintaining mobility are important for extending healthy life expectancy and reducing long-term care demands (Nakamura & Ogata, 2016). Preventing muscle weakness in the lower limbs due to sarcopenia is crucial in extending healthy life expectancy. Sarcopenia is an age-related loss of muscle mass and strength; type II fibre atrophy is more predominant than inactive muscle atrophy, and the muscle fibres not only atrophy but also decrease in number (Rosenberg, 1997; Ezaki, 2012). The vastus medialis obliquus (VMO) has a higher percentage of type II fibres than of type I fibres (Travnik et al.,1995). Resistance training increases the number and size of type II fibres; therefore, it is a method for sarcopenia prevention (Charette et al.,1991).

One method of strengthening the quadriceps muscles, which are significantly affected by sarcopenia, is squatting exercises. Numerous studies have examined the relationship between lower-limb muscle activity and the knee joint angle, knee joint position (i.e., whether the knee joint is placed in front of the toes), trunk tilt angle, and centre of gravity (COG) during squatting exercises (Nakamura & Ogata, 2016; Fry et al., 2003; Gullett et al., 2009). However, the characteristics of quadriceps activity at different trunk tilt angles during squatting have not been fully investigated.

In this study, we aimed to evaluate the relationship between the trunk tilt angle and knee joint position while squatting and the quadriceps activity. We also aimed to determine the squatting position suitable for patients with sarcopenia with selective atrophy of the VMO, which has a high percentage of type II fibres that are predominantly atrophic in sarcopenia.

METHODS

Participants

This study was approved by the Kibi International University Research Ethics Review Committee (Approval No. 17-19). The purpose of this study was explained to the participants, and their consent was obtained before the study was conducted.

The participants were 24 healthy young males and females (18 males and 6 females; mean age, 21.7 ± 1.0 years, body mass index 22.1 ± 3.1%) who did not report back or knee pain at the time of evaluation.

Squat measurement position

The squatting measurement positions were set with the knee joint at 60° flexion using two factors: the position of the knee joint (i.e., the tip of the knee was either in front of the toes or aligned with the toes) and the tilt angle of the trunk. The knee joint was set at 60° flexion because the squat was performed in a mildly flexed position, which is easy for olde adult patients prone to sarcopenia to perform, and the flexion angle for the maximum total compressive load at the tibiofemoral joint was not reached (approximate maximum range: 70°–110°) (Mündermann et al., 2008).

In the forward knee group (group F), the tip of the knee was allowed to go in front of the toes; the three positions were 0° forward inclination (F0), 20° forward inclination (F20), and 40° forward inclination (F40), where the line connecting the acromion and greater trochanter was in front of the vertical line. In the backward knee group (group B), the knee apex and toes were aligned, and the line connecting the acromion and greater trochanter was inclined 20° anterior to the vertical line (B20) or 40° anterior to the vertical line (B40) (Figure 1).

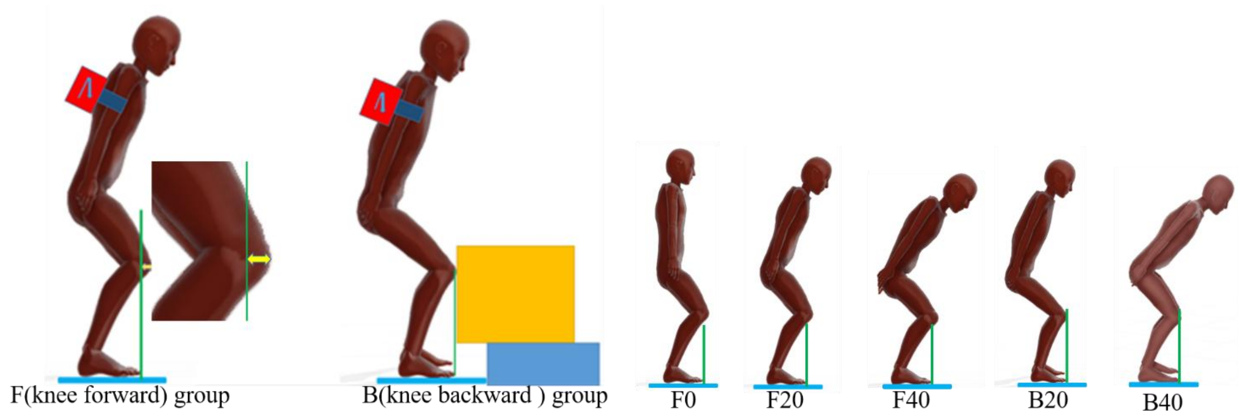


Figure 1. Limb positions during measurements.

In group F (knee forward group), the tip of the knee was allowed to go in front of the toes; the three positions were 0° trunk forward inclination (F0), 20° trunk forward inclination (F20), or 40° trunk forward inclination (F40). In group B (knee backward group), the kneecap and toes were aligned and inclined 20° trunk forward (B20) or 40° trunk forward (B40). Arrows (⇔) indicate the distance from the toe to the point where the front surface of the knee joint is projected onto the floor (group F).

Measurement of trunk tilt and knee joint angles
The angle of trunk inclination was measured with a homemade angle meter attached to the right upper arm (Figure 2). The upper arm was positioned such that the middle of the wrist joint was at the greater trochanter when the upper limb was aligned with the body during elbow extension. The knee joint flexion angle was measured using a goniometer (Tokyo University).

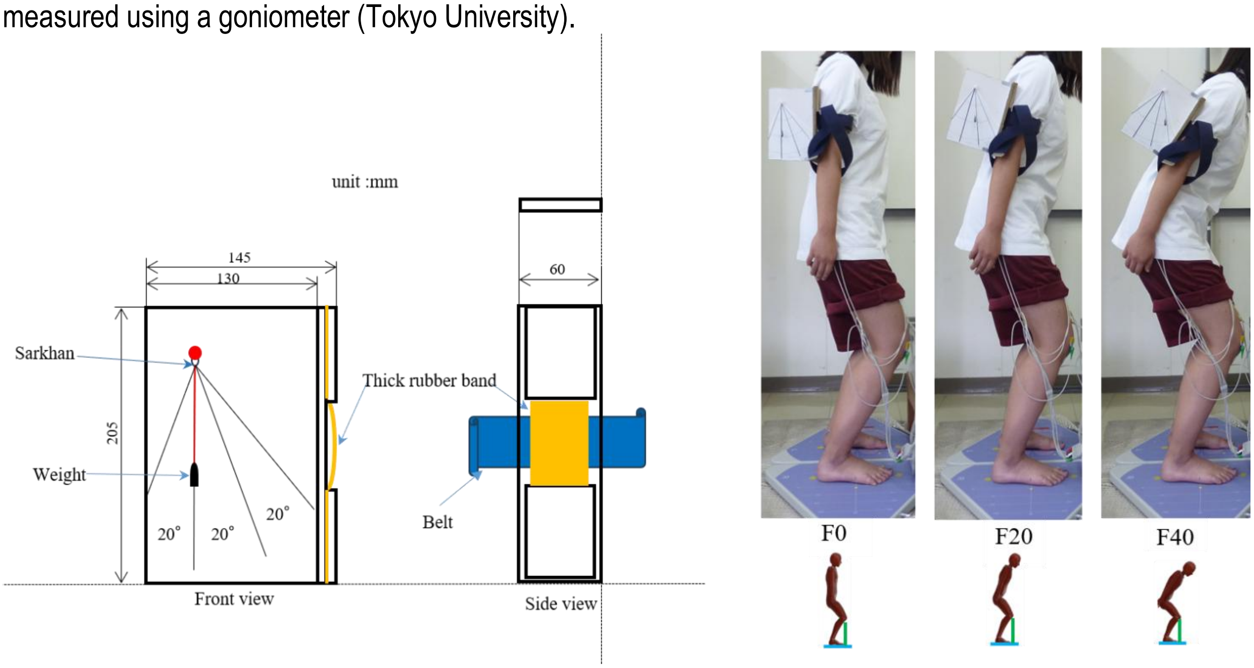


Figure 2. Angle meter for measuring the trunk tilt angle.

A weight is attached to the thread and a board with an attached angle scale. The trunk tilt angle is measured at 0°, 20°, and 40° forward tilt.

Setting the knee joint position while squatting

The distance between two points (from the toe to the point where the front surface of the knee joint is projected onto the floor) was measured in ImageJ. The distance was measured from images taken from the side (Figures 1and 2). For the squatting position in which the knee was positioned in front of the toes (group F), the patient was instructed to "*assume the squatting position with the knee forward*". For the squatting position in which the knee did not come forward in front of the toes (group B), a box placed at the toe position on the table was shown, and the participant was instructed to "*Please get into the squatting position so that your knee does not touch the box in front of you*". The position of the knee joint on the coronal plane was maintained in the middle position to avoid moving the knee in and out.

Measurement of anterior-posterior (A-P) centre of pressure (COP) of the fifth metatarsal as the origin

As the centre of gravity (COG)and COP are approximated in static standing posture (Fujiwara and Ikegami, 1981). COP was therefore used as an evaluation parameter. The A-P COP was measured using a Gravicorder G-620 (Anima, Tokyo) and captured on a PC at a sampling frequency of 20 Hz.

Two force plates were placed side by side on either side to measure A-P COP. The left and right feet were spaced such that the width of the medial margin of the bilateral anterior superior iliac spine and the width of the centre of the left and right calcanei viewed posteriorly coincided. The feet were symmetrically positioned, and the feet were oriented such that the lines connecting the medial edges of both heels and the medial edges of both first metatarsophalangeal joints were parallel. The feet were placed symmetrically such that the centre of the fifth metatarsals was aligned with the central transverse line of the detector. A 10-s measurement was taken after confirming that the measuring limb position had been taken. A-P COP was expressed as %foot length, with the posterior end of the heel to the apex of the toe representing 100%, the centre of the fifth metatarsal representing the origin, positive values representing the anterior positions, and negative values representing the posterior positions (Figure 3).

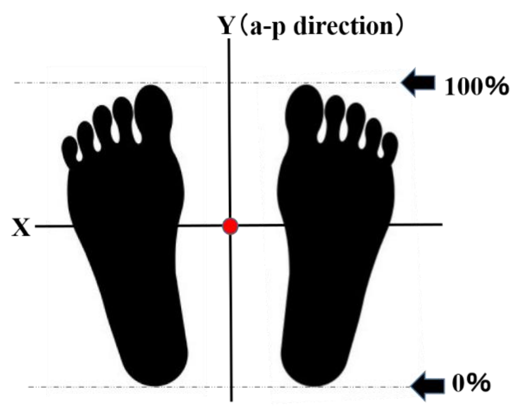


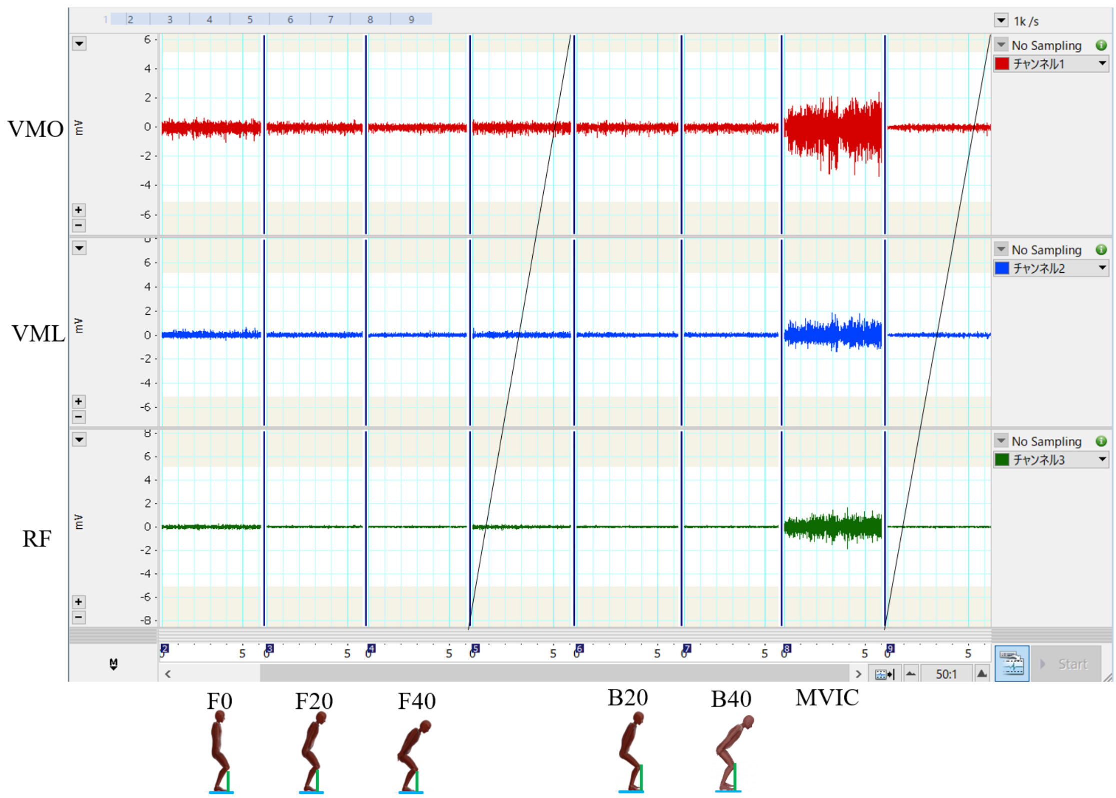
Figure 3. Measurement of anterior-posterior (A-P) centre of pressure (COP) ● Centre of pressure (red circle): %foot length.

Surface electromyography (sEMG) assessment

sEMG was used to measure muscle activity, and data were collected and analysed using the Power Lab system. The sampling frequency was 1 kHz, and the bandpass filter was set from 20 Hz to 1 kHz.

The activities of the VMO, vastus medialis longus (VML), and rectus femoris (RF) were measured. The VMO conductor was placed approximately 2 cm medial to the superior patella along the course of the muscle fibres, with a slope of approximately 55°. The VML conductor was placed on the muscle belly, the width of four fingers from the superior border of the patella. The RF conductor was placed in the muscular belly approximately in the middle of the line connecting the superior anterior iliac spine and the knee joint.

The EMG potentials were measured for 6 s at each limb measurement position, and the middle 3 s of the stabilized EMG potentials were integrated after rectification to obtain an integrated EMG (IEMG) value. The MVIC of the quadriceps was measured in the sitting posture with the trunk tilted 30° posterior to the vertical line and the knee joint flexed at 40°. Resistance was applied at the distal surface of the front lower leg to extend the knee joint. The EMG integral value of the maximum voluntary isometric contraction (MVIC) of each muscle was determined, and the IEMG of each muscle was divided by the MVIC to obtain the %MVIC (Figure 4).



VMO: vastus medialis obliquus; VML: vastus medialis longus; RF: rectus femoris; MVIC: maximum voluntary isometric contraction. In group F (knee forward group), the tip of the knee was allowed to go in front of the toes; the three positions were 0° trunk forward inclination (F0), 20° trunk forward inclination (F20), or 40° trunk forward inclination (F40). In group B (knee backward group), the kneecap and toes were aligned and inclined 20° trunk forward (B20) or 40° trunk forward (B40).

Figure 4. Representative example showing electromyograms for each limb position.

Procedures

Measurements were taken at F0, F20, F40, B20, and B40, in that order. Before measuring A-P COP, the 60°flexion position of the knee joint was confirmed with a goniometer and the knee joint position was photographed. A-P COP measurements were performed for 10 s. sEMG measurements were performed for 6 s during A-P COP measurements. MVIC measurements were taken after A-P COP measurements were completed. Rest breaks were taken as needed.

Statistical analysis

One-way analysis of variance and multiple comparison tests with repeated measures (Bonferroni method) were performed for muscle activity, A-P COP and knee position while squatting according to trunk tilt angle. Statistical analyses were performed using IBM SPSS Statistics Base for Windows (Version 24,29 for Windows; IBM, Armonk, NY, USA). For all statistical tests, $p < .05$ was considered significant.

RESULTS

The VMO activity on sEMG was significantly higher for F0 than for F20, F40, B20, or B40. The VML %MVIC was significantly higher for F0 than for B40. No significant differences were observed between the other groups. The RF activity was significantly higher for F0 than for F20, F40, B20, or B40 (Table 1).

Table 1. Comparison of muscular activity (%MVIC) according to trunk tilt.

Variable	Comparison target		Mean	Standard deviation	Standard error	*p*-value	95%CI
	Trunk tilt vs Trunk tilt						Lower − Upper
VMO%MVIC (%)	F0	F0	21.23	11.24	2.30	−	16.49 − 25.98
		F20	17.05	9.73	1.99	<.001*	12.94 − 21.16
		F40	15.89	9.31	1.90	.005*	11.96 − 19.83
		B20	17.13	9.70	1.98	.001*	13.04 − 21.22
		B40	16.14	8.40	1.72	.012*	12.59 − 19.69
VML%MVIC (%)	F0	F0	19.21	12.65	2.58	−	13.87 − 24.56
		F20	16.16	12.33	2.52	.43	10.96 − 21.37
		F40	14.43	10.11	2.07	.24	10.16 − 18.70
		B20	15.82	10.54	2.15	.69	11.37 − 20.28
		B40	14.04	8.40	1.71	.04*	10.49 − 17.59
RF%MVIC (%)	F0	F0	13.91	7.6	1.55	−	10.71 − 17.11
		F20	9.21	5.5	1.11	<.001*	6.91 − 11.52
		F40	8.33	5.2	1.05	.002*	6.15 − 10.51
		B20	9.88	6.3	1.29	.003*	7.21 − 12.56
		B40	8.76	5.4	1.11	.003*	6.47 − 11.06

*Note. *: p < .05 (vs F0).*

The A-P displacement of the COP was significantly more posterior in B20 than in F20, F40, and B40 (Table 2). F0 was the value with the smallest displacement of the COP in the A-P direction.

Table 2. Comparison of A-P COP according to trunk tilt.

Variable	Comparison target		Mean	Standard deviation	Standard error	*p*-value	95%CI
	Trunk tilt vs Trunk tilt						Lower − Upper
A-P COP (%)	B20	F0	-0.04	2.22	0.45	.07	-0.98 − 0.90
		F20	0.36	2.66	0.54	.005*	-0.77 − 1.48
		F40	0.66	2.61	0.53	.002*	-0.44 − 1.76
		B20	-2.04	2.36	0.48	−	-3.04 − -1.04
		B40	-0.82	2.25	0.46	.006*	-1.77 − 0.13

*Note. *: p < .05 (vs B20).*

The distance from the toe to the point of the knee apex projected onto the floor was significantly more anterior for F0 than for F20 and F40 (Table 3).

Table 3. Comparison of Knee position according to trunk tilt.

Variable	Comparison target		Mean	Standard deviation	Standard error	*p*-value	95%CI
	Trunk tilt vs Trunk tilt						Lower－Upper
Knee position (cm)	F0	F0	5.78	1.85	.38	－	5.00－6.57
		F20	2.85	3.03	.62	<.001*	1.58－4.13
		F40	2.05	2.21	.45	<.001*	1.11－2.98

*Note. *: p < .05 (vs F0).*

Tables 1-3. n = 24 for each group. Statistical analysis: Bonferroni method. 95% CI: 95% confidence interval values. In group F (knee forward group), the tip of the knee was allowed to go in front of the toes; the three positions were 0° trunk forward inclination (F0), 20° trunk forward inclination (F20), or 40° trunk forward inclination (F40). In group B (knee backward group), the kneecap and toes were aligned and inclined 20° trunk forward (B20) or 40° trunk forward (B40).

DISCUSSION

The %MVIC values for the VMO and RF were significantly greater for F0 than for F20, F40, B20, or B40. The %MVIC value of the VML was significantly greater for F0 than for B40. This is thought to be because the vertical distance between the COG and the centre of rotation of the knee joint (moment arm) is longer in the vertical trunk position than in the anterior trunk leaning position, resulting in a larger knee extension moment.

At B20, where the knee is in line with the toes, the COP is significantly posterior than in F20, F40, and B40. This may be due to the fact that B20 is a limb position with a small anterior tilt angle between the lower leg and trunk, causing the COG to move backwards. The posture of an older adult person in a stationary standing position has a COG that is shifted backward compared to the position of the centre of foot pressure, owing to kyphosis of the thoracolumbar spine and backward tilt of the pelvis (Elble et al.,1997). Squatting, which involves a small forward trunk tilt angle and does not allow the tip of the knee to go beyond the toes, is an exercise that increases the risk of falling backward.

This study had some limitations. The trunk tilt angle in this study was not a direct measure of spinal alignment. Therefore, cases in which the trunk tilt angle was compensated for by flexion and extension of the thoracolumbar spine were judged from the images and excluded from the measurement data.

CONCLUSION

The vertical trunk position is a significant source of muscle activity for the VMO and other quadriceps muscles in squats with the knee joint flexed 60º.

COP at F0 was the limb position with the smallest A-P displacement. However, due to reasons such as the tendency of the COG of older people to move backwards, squatting with both upper limbs supporting the body is a better way to avoid the risk of falls.

AUTHOR CONTRIBUTIONS

Tetsuo Imano: Study design, data analysis, manuscript preparation. Masaaki Nakajima: Study design, data analysis.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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ETHICS STATEMENT

The experiments completed in this study comply with the current laws of the country in which they were performed.

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