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Relationship between core muscles, leg arch, hamstring and lumbar flexibility on pop-up ability among surfers

A.A. Gd Eka Septian Utama[1*], I Dewa Gd Alit Kamayoga[1], M. Widnyana[1], I Putu Yudi Pramana Putra[1]

ABSTRACT

Background: Surfing is a sport that requires alternating high, medium, and low intensity at one time. Surfing combines three phases, namely paddling, pop-up, and wave-ride. The surf pop-up phase is characterized by a change from a paddling position to a standing position on the surfboard in one dynamic motion. During this transition, a surfer must move 75% of his body weight in less than one second. Pop-up movement is a unique challenge for the human motor system because it must be done quickly, with sufficient strength, on a moving and unstable surface that requires the readiness of the bio motoric component to avoid injury. This study aimed to see the relationship between core muscles, leg arches, hamstring, and lumbar flexibility on pop-up ability among surfers.

Methods: The research uses analytic observational with a cross-sectional approach. The number of samples was 80 people with inclusion criteria, men aged 20-40 years and at least one year of surfing experience. Core muscles were measured using the curl-up test, the footprint test measured leg arches, hamstring flexibility by the sit and reach test, lumbar flexibility by the modified Schober's test, and pop-up ability using the time to pop-up. The research was conducted in Badung regency.

Results: This study showed a significant and strong relationship between core muscles (r= 0,57, p-value< 0.001), leg arches (r_s= 0.33-0.43, p-values= 0.009 - <0.001), hamstring and lumbar flexibility (r_s= 0.31-0.50, p-values= 0.013 - <0.001) on pop-up ability among surfers.

Conclusion: There were significant relationships between the core muscles, leg arches, hamstring and lumbar flexibility on pop-up ability among surfers.

Keywords: core muscles, hamstring flexibility, leg arcs, lumbar flexibility, pop-ups, surfing.

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[1]Physical Therapy Department, College of Medicine, Universitas Udayana, Bali, Indonesia;

*Corresponding to:
A.A. Gd Eka Septian Utama;
Physical Therapy Department, College of Medicine, Universitas Udayana, Bali, Indonesia;
gungeka201@gmail.com

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INTRODUCTION

It is widely reported that surfers spend their time in four categories: rowing, stationary, riding on waves, etc. Recreational and professional surfers can spend around 50%, 40%, 3%, and 7%, respectively.[1] Surfing involves three important phases: paddling, pop-up, and wave-ride. The surf pop-up phase is characterized by changing from a prone rowing position to a surf-specific stance in one dynamic motion. During this transition, a surfer must move around 75% of his body weight in less than one second.[2]

Pop-up movements are a unique challenge to the human motor system, as they must be performed quickly, with sufficient force, on a moving and unstable surface. Isometric hyperextension during pedaling and pop-ups (rapid movements from pedaling to standing on a surfboard) are mentioned as possible causes of low back pain due to kinetic and functional changes in the chest and lower back.[3]

Surf injuries are becoming more relevant to globalization and the sport's increasing risks. However, little is known about surfing injuries or prevention strategies in either competitive or recreational surfing. Previous research showed that surfers were injured at a frequency of 0.74-1.79 injuries per 1000 hours of surfing. On head/face/neck and knee 10.4%.[2]

Mendez-Villanueva and Bishop[4] discuss the importance of balancing muscle and strength flexibility of the shoulders, abs, back, and hamstrings, with imbalances indicating a predisposing factor for injury in surfers. According to Eurich et al., detailed knowledge of the techniques and physical demands required for a good pop-up.[3] It is important to prevent injury, train effectively, and improve performance. Studies examine full-body movement and strength of the upper and lower extremities during the pop-up because it is both necessary and still lacking. Research by Downs[5] examines the transient effects of core stability exercises on postural sways during quiet standing and shows that the COP trajectory decreased immediately after exercise core stability.

Based on the background above, it is necessary to research the factors that influence pop-up movements to improve the ability of surfers and prevent injuries to surfers. So that researchers are interested in taking the title relationship of core muscles, leg arches, hamstring and lumbar flexibility to pop-up ability in surfers.

METHODS

This study is an analytic observational study using a cross-sectional approach. Before patients were recruited, this study was approved by the Faculty of Medicine, Udayana University/Sanglah Hospital Denpasar, with ethical clearance number 1396/UN14.2.2.VII.14/LT/2022. All respondents were given an explanation of the procedures and benefits of this study before the study started. Participants in this study were a population of surfers in Badung Regency, Bali, Indonesia. The eligibility criteria in this study were men aged 20-40 years who had been surfing for at least one year. Someone who has a musculoskeletal injury or is under treatment and has bone and muscle disorders was excluded from this study.

The Sampling technique used in this study is a non-probability sampling technique with a purposive sampling method. All populations that meet the eligibility criteria will be the research sample. Core muscles were examined with the curl-up (partial sit-up) test with a reliability greater than 0.80.[6] The arch of both legs was examined by the footprint test method Clarke's test with intra-rater reliability (ICC=0.99), sensitivity (98%), and specificity (99%).[7] Hamstring flexibility was measured using the sit and reach test with criterion-related validity (0.46-0.67).[8] Lumbar flexibility was measured using the modified Schober's test validity (r=0.67) with an excellent interclass (r=0.91) and intraclass (r=95) reliability.[9] Pop-up ability on a stopwatch video record.

Core muscles are measured three times, the largest value was used. The left and right leg arches were measured in a flat place. The left and right hamstring flexibility was measured three times, then the largest value was used, followed by lumbar flexibility and pop-up ability measurement. The results of core muscle measurements are included in categories, in which the value of 17-20 times included the good category and below 17 times the bad category. The arch of the foot is included in the category with the normal category foot having a range of 31° - less than 45°, the flat foot has a range less than 31° and the cavus foot has a range of more than 45°. Hamstring flexibility was measured, and the result was 23-33 cm, including the good value category; above 33 is very good, and below 23 is less. Lumbar flexibility is included in the good category if it is more than 7.1 cm and poor if it is less than 7.1 cm. Pop-up ability is good if the value is less than 3 seconds and less if the value is more than 3 seconds. The data analysis technique used univariate test, bivariate test with chi-square, and multivariate test using logistic regression using SPSS 24 software.

RESULTS

Based on Table 1, the percentage of good core muscle is 56.3%, and bad core muscle is 43.8%. The right foot arch was 33.8% normal, 51.2 flat foot, and 15% cavus foot, while the left arch was 30% normal, 45% flat foot, and 20% cavus foot. For right hamstring flexibility, 17.5% is very good, 40% is good, and 42.5% is lacking, while for left flexibility, 20% is very good, 45% is good, and 35% is lacking. For lumbar flexibility, 75% is good, and 25% is less. The pop-up capability is 57.5% in the good category and 42.5% in the less category.

Based on Table 2, the p-value <0.001 was obtained for core muscles, p-value= 0.001 for the right leg arch, p-value= 0.009 for the left leg arch, p-value= 0.002 for right hamstring flexibility, p-value= 0.013 for left hamstring flexibility, and p-value< 0.001 for lumbar flexibility which shows that there were significant relationships between core muscles, right leg arch, right flexibility and lumbar flexibility on pop-up ability among surfers. The correlation of the core muscles was r= 0.567 (very strong), right leg arch was r= 0.428 (strong), left leg arch was r= 0.331 (strong), right hamstring flexibility was r= 0.362 (strong), left hamstring flexibility was r= 0.310 (strong), and lumbar flexibility was r= 0.496 (very strong). This shows a strong and positive relationship between core muscles, leg arches, hamstring flexibility, and lumbar flexibility on pop-up ability in surfing.

Based on Table 3, the factors with pop-up ability were removed step by step, with a p-value< 0.005 with the logistic regression test, and the final stage can be seen in Table 4, which found that the lumbar flexibility factor is the most dominant factor related to pop-up ability among the surfers.

DISCUSSION

Good core stability can improve balance and proprioception, which allows faster movements and helps direct force to the extremities, allowing smooth, controlled movements and effectively reducing compensatory movements. Core strength and stability can help maintain and control balance and may also be a protective factor in lower extremity injuries.[10]

According to Thierry et al.[11], core muscle strength is significant for optimal performance

Table 1. Characteristics of study participants.

Characteristics	Frequency	Percentage%
Core muscles		
Good	45	56,3
Bad	34	43,8
Leg arch		
Right		
Normal	27	33,8
Flat foot	41	51,2
Cavus foot	12	15
Left		
Normal	24	30
Flat foot	36	45
Cavus foot	20	25
Hamstring flexibility		
Right		
Very good	14	17,5
Good	32	40
Lacking	34	42,5
Left		
Very good	16	20
Good	36	45
Lacking	28	35
Lumbar flexibility		
Good	60	75
Less	20	25
Pop-up ability		
Good	46	57,5
Less	34	42,5

in many sports, especially surfing. This is because core muscle strength affects the stability of surfers on the board. Therefore, the core muscles also automatically affect the level of competence of the surfer's competition itself. When the core muscles are not activated, the local muscles will not function properly, and the movement will become inefficient due to compensation from the global muscles, thereby changing stability. Then this invention was further developed by expanding the division of the core muscles into muscles based on their pattern of activity, namely short muscles that only pass through one joint-segment, several bone segments where the combination of the two muscle activation patterns makes it possible to control the multi-segment spine and neutralize strength. Core strength and stability will affect the balance of the spine.[10]

Muscles with increased torso rigidity more effectively transfer force resulting in greater limb speed.[12] Surfing includes a variety of technical skills such as barrel riding, snaps, cutbacks, or aerial maneuvers, where muscle force is generated in the core and then transferred to the lower extremities to control the surfboard. To achieve the angular velocity necessary for the movement to occur in the sagittal and transverse planes, the core muscles must generate synergistic forces to transfer to the extremities and muscle rigidity to stabilize the spine against disturbances caused by external forces, such as movement from the sea.[13] Performance will be improved if muscle power is generated and transferred efficiently.[14]

When surfers place their feet on the simulated surfboard, the maximum load reaches about 160% of their body weight. In particular, applying a greater relative force with the forefoot will help reduce the angle of inclination of the board and keep it flat on the surface of the water. This action will help increase the speed of the fall and keep the surfer's body perpendicular to the surfboard, possibly leading to more balance and control of the surfboard through their feet. It can also help to push the surfer's center of mass down the wave slope. On the other hand, more load on the back foot will increase corner pitch, thereby increasing drag resistance and slowing surfboard speed.[15]

The surfer's stance is described as a semi-squat position with knees bent 30–80^0, with the back knee in the valgus position. The current results generally support this description but show a higher angle of knee flexion and a lack of consistency among surfers regarding foot placement.[11] When a person experiences an abnormal arch of the foot, the problem is if the position of the sole shifts or loses its alignment because it will affect the body's structure. When the alignment of the body changes, the center of gravity of the body will change. The function of the center of gravity (COG) is to distribute the mass of objects evenly, such as in the human body, the COG always supports the body's weight, so the body is in a state of balance. But if there is a change in body posture, the center of gravity changes, and it will cause an imbalance (unstable). The human arches are formed so that the feet are more stable when standing flat and distribute weight evenly to a broader area.[16] The foot arch adds elasticity and flexibility, helps the foot absorb shock, maintain balance, stand, walk, run, and jump.[17]

According to Wismanto[18], the hamstring muscles have the basic functional movement for knee flexion, as a muscle accessory for hip extension movements and external and internal movements of hip rotation movements. The hamstring is also a tonic muscle that functions as a postural stabilizer. It has thick muscle fibers with a high myoglobin content and oxidative capacity to resist relatively high fatigue. Decreased musculoskeletal abilities can reduce physical activity and exercise. Meanwhile, to be able to perform daily activities efficiently requires adequate flexibility of the

Table 2. **Bivariate *Chi-square* test.**

Characteristics	Pop-up ability				Total		*P*-value	r
	Good		Less					
	F	%	F	%	F	%		
Core muscles								
Good	37	82.2	8	17.8	45	100		
Bad	9	25.7	26	74.3	35	100	0.000	0.567
Total	46	57.5	34	42.5	80	100		
Right leg arch								
Normal	22	81.5	5	18.5	27	100		
Flat foot	22	53.7	19	46.3	41	100	0.001	0.428
Cavus foot	2	16.7	10	83.3	12	100		
Total	46	57.5	34	42.5	80	100		
Left leg arch								
Normal	18	75	6	25	24	100		
Flat foot	22	61.1	14	38.9	36	100	0.009	0.331
Cavus foot	6	30	14	70	20	100		
Total	46	57.5	34	42.5	80	100		
Right hamstring flexibility								
Very goo[d]	11	78.6	3	21.4	14	100		
Good	23	71.9	9	28.1	32	100	0.002	0.362
Lacking	12	35.3	22	64.7	34	100		
Total	46	57.5	34	42.5	80	100		
Left hamstring flexibility								
Very good	12	75	4	25	16	100		
Good	24	66.7	12	33.3	36	100	0.013	0.310
Lacking	10	35.7	18	64.3	28	100		
Total	46	57.5	34	42.5	80	100		
Lumbar flexibility								
Good	43	71.7	17	28.3	60	100		
Less	3	15	17	85	20	100	0.000	0.496
Total	46	57.5	34	42.5	80	100		

Table 3. **Initial modeling results of factors associated with pop-up ability among surfers.**

Characteristics	B	*P*-value	OR	95% CI	
				Lower	Upper
Core muscles	2.450	0.001	11.588	2.663	50.418
Right leg arch	1.236	0.051	3.442	0.994	11.917
Left leg arch	0.716	0.205	2.046	0.676	6.195
Right hamstring flexibility	0.745	0.384	2.107	0.394	11.273
Left hamstring flexibility	0.707	0.450	2.028	0.324	12.674
Lumbar flexibility	2.914	0.003	18.424	2.688	126.294
Constant	-14.441	0.000	0.001		

B, betta; CI, confidence interval; OR, odd ratio.

Table 4. **Final modeling results of factors associated with pop-up ability among surfers.**

Characteristics	B	*P*-value	OR	95% CI	
				Lower	Upper
Core muscles	2.374	0.001	10.737	2.589	44.527
Right leg arch	1.536	0.009	4.647	1.479	14.606
Right hamstring flexibility	1.281	0.012	3.600	1.318	9.835
Lumbar flexibility	2.557	0.004	12.896	2.298	72.356
Constant	-14.441	0.000	0.000		

B, betta; CI, confidence interval; OR, odd ratio.

hamstring muscles. If the muscles experience shortening, it will affect the balance of muscle work it can cause activity disturbances.

Previous studies[14,19] explained that the hamstring muscle function as a postural stabilizer was closely related to the lumbar-pelvic spine, upper torso, and shoulder. Then, if the hamstring muscle experiences tightness, it will impact the thoracolumbar fascia and interfere with the movement of the sacroiliac joint. Moreover, a decrease in hamstring flexibility could affect the pop-up ability of surf players who need balance from the lumbar-pelvic spine, upper extremity, and sacroiliac joint to do it quickly.

The flexibility of the lumbar muscles is the maximum ability of the muscles in the lumbar region to move the joints within their range of motion. The spine is a good support for the body because it has two types of stabilizers (intrinsic stabilizers and extrinsic stabilizers). In trunk flexibility, flexibility is needed in the back muscles, abdominal muscles, tendons, ligaments, and joints. Lack of flexibility of these muscles will result in a limited range of motion of the joints (ROM) due to the strength of the muscles and tendons, which can cause joint contractures. Adequate levels of flexibility can improve lumbar mobility and individual functional ability and reduce the likelihood of developing muscle strain.[20]

Pop-up acceleration (a quick movement from paddling to standing on a surfboard) is the physical relationship between the acceleration and the tension force exerted during the campaign, as it is an intense and explosive twisting and compressing of the lumbar spine.[21] Changes in the lumbar will result in loss of lumbar lordosis resulting in a decrease in lumbar flexibility. Loss of lumbar lordosis causes hip retroversion and a posterior shift of the line of gravity. Loss of lumbar lordosis increases postural instability and a tendency to fall in adults with osteoporosis. This is because the loss of lumbar lordosis and thoracic hyperkyphosis will induce a displacement of the line of gravity in the sagittal plane, reducing the stability limit in all directions and the magnitude of the response and velocity of displacement, especially in the anteroposterior axis.[22]

CONCLUSION

This study concludes that there was a strong and positive relationship between core muscles, leg arches, hamstring, and lumbar flexibility on pop-up ability among surfers. In addition, further research is needed regarding variables that can confound our findings, such as daily activities, nutrition, surfing intensity, smoking, and the factors that can cause surfer injuries.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

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AUTHOR CONTRIBUTIONS

AAGESU compiled the study design, data collection, and data analysis and drafted the manuscript; IDGAK, MW, and IPYPP participated in the literature search, drafting, and revising of the manuscript. All authors have read and approved the final version of the manuscript.

REFERENCES

1. Farley OR, Harris NK, Kilding AE. Physiological demands of competitive surfing. The Journal of Strength & Conditioning Research. 2012;26(7):1887-96.
2. Parsonage J, Secomb J, Dowse R, Ferrier B, Sheppard J, Nimphius S. The assessment of isometric, dynamic, and sports-specific upper-body strength in male and female competitive surfers. Sports. 2018;6(2):53.
3. Eurich AD, Brown LE, Coburn JW, Noffal GJ, Nguyen D, Khamoui AV, et al. Performance differences between sexes in the pop-up phase of surfing. The Journal of Strength & Conditioning Research. 2010;24(10):2821-5.
4. Mendez-Villanueva A, Perez-Landaluce J, Bishop D, Fernandez-Garcia B, Ortolano R, Leibar X, et al. Upper body aerobic fitness comparison between two groups of competitive surfboard riders. Journal of Science and Medicine in Sport. 2005;8(1):43-51.
5. Downs DA. A comparison of the effects of four conditioning regimens on postural sway. Medicine & science in sports & exercise. 2011;43(5):525-6.
6. Jackson AW, Morrow Jr JR, Brill PA, Kohl III HW, Gordon NF, Blair SN. Relations of sit-up and sit-and-reach tests to low back pain in adults. Journal of Orthopaedic & Sports Physical Therapy. 1998;27(1):22-6.
7. Hegazy F, Aboelnasr E, Abuzaid M, Kim I-J, Salem Y. Comparing validity and diagnostic accuracy of Clarke's angle and foot posture index-6 to determine flexible flatfoot in adolescents: A cross-sectional investigation. Journal of Multidisciplinary Healthcare. 2021:2705-17.
8. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: a meta-analysis. Journal of sports science & medicine. 2014;13(1):1.
9. Rezvani A, Ergin O, Karacan I, Oncu M. Validity and reliability of the metric measurements in the assessment of lumbar spine motion in patients with ankylosing spondylitis. Spine. 2012;37(19):E1189-E96.
10. Huang TH, Chang H-Y, Lu SY, editors. Quantified movement test of core muscles for Athletes. ISBS-Conference Proceedings Archive; 2016.
11. Paillard T, Margnes E, Portet M, Breucq A. Postural ability reflects the athletic skill level of surfers. European journal of applied physiology. 2011;111:1619-23.
12. Okada T, Huxel KC, Nesser TW. Relationship between core stability, functional movement, and performance.

The Journal of Strength & Conditioning Research. 2011;25(1):252-61.

13. Granacher U, Schellbach J, Klein K, Prieske O, Baeyens J-P, Muehlbauer T. Effects of core strength training using stable versus unstable surfaces on physical fitness in adolescents: a randomized controlled trial. BMC sports science, medicine and rehabilitation. 2014;6(1):1-11.
14. Shinkle J, Nesser TW, Demchak TJ, McMannus DM. Effect of core strength on the measure of power in the extremities. The Journal of Strength & Conditioning Research. 2012;26(2):373-80.
15. Borgonovo-Santos M, Telles T, Nessler J, de Castro MP, Fernandes RJ, Vilas-Boas JP. Are the kinetics and kinematics of the surf pop-up related to the anthropometric characteristics of the surfer? Sensors. 2021;21(5):1783.
16. Syafi'i M, Pudjiastuti SS. Beda Pengaruh Arkus Kaki terhadap Keseimbangan Statis Anak Usia 9-12 Tahun di SD Negeri Mojolegi, Teras, Boyolali. Jurnal Kesehatan. 2016;7(3):351-4.
17. Erol K, Karahan AY, Kerimoğlu Ü, Ordahan B, Tekin L, Şahin M, et al. An important cause of pes planus: the posterior tibial tendon dysfunction. Clinics and practice. 2015;5(1):699.
18. Wismanto W. Pelatihan Metode Active Isolated Stretching Lebih Efektif Daripada Contract Relax Stretching dalam Meningkatkan Fleksibilitas Otot Hamstring. Jurnal Fisioterapi. 2011;11(1).
19. Hoskins W, Pollard H. The management of hamstring injury—Part 1: Issues in diagnosis. Manual therapy. 2005;10(2):96-107.
20. Kurniawan EY, Kesoema TA, Hendrianingtyas M. Pengaruh Latihan Fleksi Dan Ekstensi Lumbal Terhadap Fleksibilitas Lumbal Pada Dewasa Muda. Jurnal Kedokteran Diponegoro (Diponegoro Medical Journal). 2019;8(1):161-70.
21. Hammer RL, Loubert PV. Alternative pop-up for surfers with low back pain. North American journal of sports physical therapy: NAJSPT. 2010;5(1):15.
22. Fernandes VLS, Ribeiro DM, Fernandes LC, Menezes RLd. Postural changes versus balance control and falls in community-living older adults: a systematic review. Fisioterapia em movimento. 2018;31.