Clinical characteristics of spinning-induced rhabdomyolysis and other causes of rhabdomyolysis: a comparative study

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Abstract

Introduction: Spinning is an indoor stationary cycling programme that can cause severe rhabdomyolysis. We compared the clinical characteristics of spinning-induced exertional rhabdomyolysis (SER) with other exertional rhabdomyolysis (ER) and non-exertional rhabdomyolysis (NER).

Methods: This was a retrospective observational study of adult patients presenting with rhabdomyolysis to an emergency department from August 2018 to August 2019. Patients were classified as SER, ER or NER based on chart review. We compared patient demographics, serum creatine kinase (CK), transaminase and creatinine levels, admission rates, duration of hospitalisation and treatment prescribed.

Results: 62 patients were analysed. SER patients were predominantly female (77% vs. 24% vs. 26%, P < 0.01), Chinese (100% vs. 47% vs. 79%, P < 0.01) and younger (mean age 27.7 vs. 34.6 vs. 59.4 years, P < 0.01) than those with ER and NER. The SER group had the highest CK level (20,000 vs. 10,465 vs. 6,007 U/L, P < 0.01) but the lowest mean serum creatinine level (53.5 vs. 80.9 vs. 143.5 µmol/L, P < 0.01) compared to the ER and NER groups. Admission rates were the highest in SER patients (100% vs. 57% vs. 90%, P < 0.01). SER mean inpatient length of stay was longer than ER but shorter than NER patients (4.3 vs. 1.9 vs. 6.0 days, P = 0.02).

Conclusion: SER is a unique form of rhabdomyolysis. Predominantly seen in young, healthy women, it often presents with extremely high CK levels. However, the prognosis is good and the rate of complication is low with fluid treatment.

Keywords: Exertional, rhabdomyolysis, spinning

INTRODUCTION

Rhabdomyolysis is a pathological condition in which skeletal muscle necrosis occurs, resulting in leakage of intracellular muscle contents, such as myoglobin and creatinine kinase, into the circulation. Common causes include crush injuries, heat injuries, toxins and overexertion.[1,2]

Spinning is a high-intensity indoor cycling programme on stationary bicycles that requires intense and repetitive use of large muscle groups of the lower body, including the gluteus maximus and quadriceps.[3] While participants in a class are allowed to tailor the level of intensity, cadence and resistance to their fitness level, it is easy to succumb to peer pressure and overexert during the activity. Those who are unaccustomed to high-intensity exercise are the most at risk for developing spinning-induced exertional rhabdomyolysis (SER).[4] Patients typically present with thigh muscle pain and swelling, leg weakness and tea-coloured urine.[5] Spinning can cause severe rhabdomyolysis, typically with very high serum creatine kinase (CK) levels, putting patients at risk for serious complications.[6] It is, therefore, essential that this entity is recognised and treated aggressively, as it is a potentially life-threatening condition.[7]

The aim of this paper was to compare and contrast the clinical characteristics of SER, exertional rhabdomyolysis from other causes (ER) and non-exertional rhabdomyolysis (NER) presenting to the emergency department (ED).

Access this article online

Quick Response Code: Website: https://journals.lww.com/SMJ
DOI: 10.11622/smedj.2021116

How to cite this article: Shroff K, Gunasegaren M, Norbu K, Omar E. Clinical characteristics of spinning-induced rhabdomyolysis and other causes of rhabdomyolysis: a comparative study. Singapore Med J 2022;63:567-71.
METHODS
This was a retrospective study of adult patients (>18 years) presenting to the ED of Sengkang General Hospital from August 2018 to August 2019 with a SNOMED Clinical Terms diagnosis of 'rhabdomyolysis'. Out of 63 patients, one was excluded from the study, as the diagnosis at final discharge was 'myositis'. The remaining 62 patients were classified as SER, ER or NER based on chart review conducted to ascertain the cause of rhabdomyolysis. Patient demographics and clinical data, including statin usage, time from activity to presentation, initial serum CK, creatinine, aspartate transaminase (AST) and alanine transaminase (ALT) levels, time taken for CK to drop below 20,000 U/L (the threshold CK level reported by the study institution’s laboratory), inpatient length of stay and treatment, were obtained via the electronic medical record. The time taken for CK level to drop below 20,000 U/L was taken as the number of days to the last reading of CK >20,000 U/L. Results were expressed either as number and percentage, or mean ± standard deviation.

Statistical analysis was conducted using SPSS version 17.0 for Windows (SPSS Inc, Chicago, IL, USA). Comparison between the three groups was done using Pearson’s Chi-square test for categorical variables and one-way ANOVA for continuous variables. Statistical significance was taken at two-sided P value <0.05. This study was approved by the Institutional Review Board at SingHealth, Singapore (CIRB reference 2020/2165).

RESULTS
During the one-year study period, 62 patients presented to the ED with rhabdomyolysis. Of these, 22 had SER, 21 had ER from other activities and 19 had NER. Causes of ER in our study population included outdoor cycling, unspecified gym exercises, high-intensity interval training, squats, captain’s hall game, swimming and participation in vertical marathon. Non-exertional causes were post seizure, viral infection, drug induced (statin), falls and dehydration.

The demographics of the three groups differed significantly. Patients with SER were predominantly female (17 [77%] vs. 5 [24%] vs. 5 [26%]; P < 0.01), Chinese (22 [100%] vs. 10 [48%] vs. 15 [79%]; P < 0.01) and younger (mean age 27.7 ± 1.0 vs. 34.6 ± 2.2 vs. 59.4 ± 3.6 years; P < 0.01) compared to patients with ER and NER. Furthermore, 73% of patients in the SER group were first-time spinners, whereas 24% in the ER group reported that it was their first time engaging in the inciting activity. Statin use also differed significantly among SER, ER and NER patients (0 [0%] vs. 4 [19%] vs. 8 [42%]; P = 0.03). There was no difference in the mean body mass index among the three groups.

Although time from exercise to presentation was similar between the SER and ER groups, the mean CK level was much higher in the SER group as compared to the ER and NER groups (20,000 ± 0 U/L vs. 10,465 ± 1,896 U/L vs. 6,007 ± 1,575 U/L; P < 0.01). Mean serum AST and ALT were correspondingly highest in the SER group and lowest in the NER group. Conversely, mean serum creatinine level was lower in the SER group (53.5 ± 2.7 µmol/L vs. 80.9 ± 5.5 µmol/L vs. 143.5 ± 37.9 µmol/L; P < 0.01). All 22 patients with SER had CK readings >20,000 U/L at presentation and the time taken for their CK level to drop below 20,000 U/L was 4.7 ± 0.4 days [Figure 1].

Among all the 62 patients, 51 (82%) were admitted to the hospital for treatment, 4 (7%) discharged themselves with medical advice and 7 (11%) were discharged with outpatient follow-up. The percentage of admitted patients was highest in the SER group compared to the ER and NER groups (22 [100%] vs. 12 [57%] vs. 17 [90%]; P < 0.01). Inpatient treatment, consisting of intravenous (IV) fluids in the form of normal saline, Ringer’s lactate solution or both, was given to 56 (90%) patients. Only one patient in the SER group (admission CK >20,000 U/L) received IV sodium bicarbonate solution for urinary alkalisation. The choice of analgesia varied among the three patient groups – non-steroidal anti-inflammatory drugs (NSAIDs) were administered to 4 (18%), 7 (33%) and 1 (5%) in the SER, ER and NER groups, respectively (P = 0.02). In the SER group, only topical NSAIDs were prescribed, whereas patients in the other two groups were prescribed all other forms of NSAIDs (i.e. oral, IV, intramuscular) except topical. The mean inpatient length of stay for the SER group was longer compared to the ER group, but shorter than that of the NER group (4.3 ± 2 days vs. 1.9 ± 3 days vs. 6.0 ± 10 days; P = 0.02). Of note, none of the patients was diagnosed with compartment syndrome during their hospitalisation. Table 1 gives a summary of the baseline demographics and clinical characteristics of the patients in the three groups.

DISCUSSION
Many case reports on SER have been published, but there are few studies characterising SER to date.[3,6,7] Our study is the first to compare and contrast the clinical characteristics of rhabdomyolysis arising from three different causes.

The stark difference in patient demographics (gender, age, statin use) of the SER patients as compared to the ER and NER patients may be due to the greater social popularity of group workout programmes among younger women.[8] Cutler et al.’s study, which compared the characteristics of SER and ER in 29 adult patients, found no significant differences in age or gender between the two groups.[9] In NER, the patients are typically older (35–91 years), and older patients are more likely to have pre-existing conditions that predispose them to NER, usually from falls or sepsis rather than exercise. While some studies have described ethnic and genetic predilection to
developing rhabdomyolysis, it is difficult to conclude whether Chinese ethnicity predisposes one to developing SER without knowledge of the demographics of spin class participants in our population.\[9,10\] It is likely not the case, as this trend was not seen in the ER and NER groups.

Despite similar time from event to presentation, patients with SER have higher initial CK levels compared to those with ER or NER, which suggests a greater degree of muscle breakdown during spinning. In this study, all patients with SER were admitted to the hospital, whereas only about half of those with ER were admitted, and this is likely due to the higher initial levels of CK in SER patients. The median CK level was 20,000 (interquartile range [IQR] 16,116) U/L in admitted patients and 2,350 (IQR 18,343) U/L in patients discharged from the ED. SER patients also required a longer hospital stay for treatment and monitoring of CK levels compared to ER patients [Figure 1]. Similar trends were seen in other studies, where CK levels as high as 400,000 U/L and longer hospitalisation periods have been documented in SER patients.\[6,11\]

In NER patients, despite the significantly lower CK values, treatment of the primary pathology that led to rhabdomyolysis and other concomitant illnesses may have contributed to the longer length of stay compared to patients with SER and ER.

Physicians should look out for two major complications in SER: compartment syndrome and AKI.\[12,13\] In this study, no SER patients were diagnosed with either of these complications throughout their hospitalisation. In contrast, 4 (19%) patients with ER had mildly elevated initial creatinine levels of up to 123 µmol/L, which resolved with treatment, whereas 8 (42%)...
of the NER patients had elevated creatinine levels of up to 655 µmol/L. Despite having the lowest mean serum CK level, patients with NER had the highest creatinine levels either resulting from pre-existing renal impairment or AKI occurring due to other concomitant conditions (e.g. sepsis, dehydration, medication-induced). No patient in this study was diagnosed or treated for compartment syndrome during their hospitalisation.

AST and ALT levels were commonly measured in patients with rhabdomyolysis. In SER, AST and ALT levels seem to correspond to CK levels and are unlikely a marker of liver damage but cellular damage from muscle breakdown. There is weak evidence showing their prognostic value for AKI. In one study involving earthquake victims, serum ALT >259 IU/L and AST >95 IU/L on admission were found to be significantly associated with the development of AKI. Whether this applies specifically to cases of ER is yet to be determined and no specific cut-off values have been determined. As such, their utility in the diagnosis and management of ER is not clear.

Rhabdomyolysis causes AKI through two mechanisms, namely renal hypoperfusion and acidosis of the urine. Therefore, besides cessation of the insult, the suggested treatment for rhabdomyolysis is aggressive hydration to maintain renal perfusion and urinary alkalinisation. In SER and ER, patients rarely have other concomitant causes of acidosis and have no reported fluid intake restrictions. In NER, however, there might be considerations for fluid restrictive diseases such as congestive heart failure and chronic renal impairment, which may limit fluid hydration. Theoretically, acidosis from other causes such as sepsis may also be present; hence, treatment has to be modified to include the utility of bicarbonate or mannitol for urine alkalinisation to prevent renal injury. However, this was not observed in our study, as only one case of SER was treated with sodium bicarbonate therapy. The remaining patients recovered uneventfully with fluid therapy alone, indicating that alkalinisation of urine may not be necessary in SER. With respect to the analgesics prescribed, it is noteworthy that 19.3% of the study patients received NSAIDs for pain control despite the diagnosis of rhabdomyolysis. Only topical forms were used in the four SER patients administered NSAIDs, and this likely reflects the physicians’ awareness of the potential risk of AKI in the presence of extremely high CK levels.

There were some limitations to our study. First, it was a single-centre, retrospective study with a small sample size. Also, some causes of rhabdomyolysis such as heat injury were not within the spectrum of patients with rhabdomyolysis. Third, the laboratory limit for CK testing was 20,000 U/L, which limited our characterisation of CK load during first few days, and CK level was not tested every day; daily testing would have better characterised the reduction in levels with treatment. Furthermore, there was also a high percentage of missing data in some variables, such as body mass index, time from exertion to presentation and transaminase levels, which may have affected the conclusions drawn from those parameters. Finally, other possible complications such as hyperkalaemia and risk...
factors (including concomitant supplement or NSAID use prior to presentation) were not analysed. In view of these limitations, the results of our study may not be generalisable to other populations. Further studies of a prospective nature would be useful to assess the effects of treatment and the prognosis of SER as compared to other forms of rhabdomyolysis.

From the public health standpoint, knowledge of the demographics and clinical characteristics of SER is important for preventing its occurrence. A 2018 fitness survey done in the United Kingdom showed that spinning was the top group exercise programme subscribed to by female participants (74%) in three consecutive years (2016–2018). Similar national data is not available for our population, although an increase in participation for spinning classes is a notable trend observed by the authors. Health advisories should be available to warn potential participants to adequately hydrate themselves, avoid medications or supplements that may increase the risk of rhabdomyolysis or potentiate its complications, and to cease the activity if any symptoms of rhabdomyolysis develop. They should also be advised to be prudent when taking part in any exertional activities, such as by gradually building up exercise volume and intensity, and avoiding abrupt increases in training load, especially with unaccustomed activities.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES
1. Long B, Koyfman A, Gottlieb M. An evidence-based narrative review of the emergency department evaluation and management of rhabdomyolysis. Am J Emerg Med 2019;37:518-23.

2. Torres PA, Helmstetter JA, Kaye AM, Kaye AD. Rhabdomyolysis: Pathogenesis, diagnosis, and treatment. Ochsner J 2015;15:58-69.

3. Kim YH, Ham YR, Na KR, Lee KW, Choi DE. Spinning: An arising cause of rhabdomyolysis in young females. Intern Med J 2016;46:1062-8.

4. DeFilippis EM, Kleinman DA, Derman PB, DiFelice GS, Eachempati SR. Spinning-induced rhabdomyolysis and the risk of compartment syndrome and acute kidney injury: Two cases and a review of the literature. Sports Health 2014;6:333-5.

5. Fidan F, Alkan B, Uğurlu G, Boyraz E, Tosun A, Arduçğlu O, et al. Spinning-induced rhabdomyolysis: A case report and review of literature. Eur J Rheumatol 2015;2:37-8.

6. Cutler TS, DeFilippis EM, Unterbrink ME, Evans AT. Increasing incidence and unique clinical characteristics of spinning-induced rhabdomyolysis. Clin J Sport Med 2016;26:429-31.

7. Beavis EE, Bongetti EK, Martin WG, Darby J. An Australian perspective on the relationship between young women, spinning and rhabdomyolysis. Intern Med J 2017;47:235-6.

8. UK Active Research Institute. Moving communities: Active leisure trends. 2018 report. Available from: http://research.ukactive.com/wp-content/uploads/2018/06/Moving-Communities-Active-Leisure-Trends-2018.pdf. [Last accessed on 11 Sep 2020].

9. Chavez LO, Leon M, Einav S, Varon J. Beyond muscle destruction: A systematic review of rhabdomyolysis for clinical practice. Crit Care 2016;20:135.

10. Landau ME, Kenney K, Deuster P, Campbell W. Exertional rhabdomyolysis: A clinical review with a focus on genetic influences. J Clin Neuromusc Dis 2012;13:122-36.

11. Young IM, Thomson K. Spinning-induced rhabdomyolysis: A case report. Eur J Emerg Med 2004;11:358-9.

12. McKinney B, Gaunder C, Schumer R. Acute exertional compartment syndrome with rhabdomyolysis: Case report and review of literature. Am J Case Rep 2018;19:145-9.

13. Rodriguez E, Soler MJ, Rap O, Barrios C, Orfila MA, Pascual J. Risk factors for acute kidney injury in severe rhabdomyolysis. PLoS One 2013;8:e82992.

14. Knapik JJ, O’Connor FG. Exertional rhabdomyolysis: Epidemiology, diagnosis, treatment, and prevention. J Spec Oper Med 2016;16:65-71.

15. Omrani H, Najafi I, Bahrami K, Najafi F, Safari S. Acute kidney injury following traumatic rhabdomyolysis in Kermanshah earthquake victims: A cross-sectional study. Am J Emerg Med 2021;40:127-32.

16. Huerta-Alardín AL, Varon J, Marik PE. Bench-to-bedside review: Rhabdomyolysis—an overview for clinicians. Crit Care 2005;9:158-6.

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