Median and Ulnar Nerve Injuries in Cyclists: A Narrative Review

Follow this and additional works at: https://www.biomedicinej.com/biomedicine

Part of the Nervous System Diseases Commons, and the Sports Sciences Commons

This work is licensed under a Creative Commons Attribution 4.0 License.

Recommended Citation
Sirisena, Dinesh C.; Sim, Shauna H-S; Lim, Ivan; and Rajaratnam, Vaikunthan (2021) "Median and Ulnar Nerve Injuries in Cyclists: A Narrative Review," BioMedicine: Vol. 11 : Iss. 4 , Article 1.
DOI: 10.37796/2211-8039.1143

This Review Articles is brought to you for free and open access by BioMedicine. It has been accepted for inclusion in BioMedicine by an authorized editor of BioMedicine.
Median and Ulnar Nerve Injuries in Cyclists: A Narrative Review

Cover Page Footnote
N/A

This review article is available in BioMedicine: https://www.biomedicinej.com/biomedicine/vol11/iss4/1
Median and ulnar nerve injuries in cyclists: A narrative review

Dinesh C. Sirisena a,b,*, Shauna H-S Sim a, Ivan Lim b, Vaikunthan Rajaratnam a

a Department of Orthopaedics and Sports Medicine, Khoo Teck Puat Hospital, Singapore
b Yong Loo Lin Medical School, National University of Singapore, Singapore

Abstract

Cycling is popular internationally as a mode of transport and sport. Cyclists often report sensory and motor changes in the hands during rides. In the past, assessment of these symptoms was based on clinical history, physical examination and neurophysiology. The aim of this narrative review was to evaluate existing publications and determine if there are areas for further improvement in the clinical setting.

Methods: Searches were undertaken in accordance with the PRISMA guidelines using four online databases: PUBMED, OVID, CINAHL and WEB OF SCIENCE. Articles were evaluated using adapted versions of guidelines for case and cohort studies.

Results: 2630 articles were found and 13 were included in the review. 2 considered median, 9 considered ulnar and 2 assessed both nerves. 11 were case and 2 were cohort studies. 7 discussed neurophysiology and 1 mentioned ultrasound as a modality of investigation. Interventions were described in 3 articles.

Conclusion: The quality of evidence is generally low when considering this problem. Clinical assessment and neurophysiology are commonly regarded as the method for assessing nerve symptoms amongst cyclists. Advances in musculoskeletal ultrasound add to our early investigative repertoire and may help expedite management and limit future disability. In addition, further research is required into screening and preventative measures amongst cyclists.

Keywords: Cycling, Median nerve, Ulnar nerve, Compressive neuropathy, Ultrasound, Screening

1. Introduction

Peripheral nerve injuries are common in athletes, occurring anywhere in the body and usually due to direct nerve trauma, sudden traction [1], or a compressive force [2]. Cycling is an increasingly popular activity that people have adopted as transportation, a pastime, or sport. It is estimated that over 7 million people cycle in the United Kingdom weekly [3], while there are nearly 800,000 commuter cyclists daily in the United States [4]. In Singapore, a government survey estimated that 125,000 people cycle regularly [5]. A variety of subcategories (including road, mountain, cyclo-cross, BMX, or track) cater to individual preferences, each with a unique environment [6,7] and associated physical challenges, yet the mechanics and biomechanics remain constant [8]. Primarily intended for directional change and guiding the bicycle, the rider controls the front of the frame via the handlebars. The seat and pedals are rear contact points that carry the rider and produce propulsion [9]. The rider must effectively manage all these intrinsic aspects and also navigate various environmental obstacles.

While cycling is an excellent way of keeping fit and healthy [10–12], it can lead to various injuries from an acute incident or chronic exposure to riding. Common areas where symptoms develop include the back, knees, and shoulders, particularly if the bicycle has not been correctly adjusted to the rider [13]. Cycling may also cause nerve injuries, leading to impotence in male riders [14]. However, the hands are more commonly affected, with injury to the median and ulnar nerves (M&UN), resulting in sensory alterations such as numbness (paresthesia), pain, and muscle atrophy. Dubbed “cyclist’s palsy” [15], this condition can occur acutely,
following a single prolonged episode of cycling or after repeated exposure with excessive pressure on the handlebars from a wrong frame size, poor positioning, or overall conditioning of the rider [16]. Often dismissed by cyclists as “part of the ride,” the increasing popularity of this activity will likely mean that cyclist’s palsy will be a more frequent pathology in the future. It is important that rehabilitation specialists, sports physicians, and hand surgeons who encounter riders with these symptoms be aware of the problem and treat it accordingly.

This review aims to summarize existing clinical knowledge of cyclist’s palsy, including investigations that confirm the changes and appropriate treatments to limit the functional impact on the individual.

2. Methods

A literature search of the medical databases PubMed, Ovid, CINAHL, and Web of Science was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [17]. The following MeSH terms (bicyclist, median nerve, ulnar nerve, median neuropathy, and ulnar neuropathy) were incorporated with additional synonyms (Cyclist, Cycling, and Bicycling) (Table 1) and executed using a Boolean search (Cyclist OR Bicyclist OR Cycling OR Bicycling) AND (Median nerve OR Ulnar nerve OR Median neuropathy OR Ulnar neuropathy).

2.1. Review process

Articles were imported into Endnote X9.3.3 (Clarivate Analytics, Philadelphia, PA, USA), duplicates were eliminated, and two study members (DS and SS) examined titles and abstracts for suitability. Full texts identified in the screening were then evaluated before disagreements were resolved by consensus. Authors IL and VR further evaluated the screened articles. References of relevant papers were checked for additional studies.

2.2. Inclusion and exclusion criteria

Seminal articles that included the search criteria were chosen and formed the foundation for other papers that cited them. Since this was a narrative review, any studies that described M&UN injury, involvement, or neuropathy with cycling were included. All non-cycling-related nerve articles were excluded.

Inclusion criteria were studies with human subjects over 18 years, articles focused on assessing median or ulnar nerve pathologies in cyclists, and articles published in English in peer-reviewed journals. Non-peer-reviewed journals and review articles, anatomical studies, and studies that do not focus on median or ulnar nerve symptoms, did not perform research in cyclists, or had no abstract or English translation were excluded.

2.3. Study analysis

Articles were analyzed according to which nerve (median, ulnar, or both) was considered, the type of riding of the subjects, if any inciting event had precipitated the symptoms, the assessments or investigations undertook, interventions that were required, and the key findings from the study. The level of evidence for each article was graded according to the Oxford CEBM Levels of Evidence [18].

2.4. Quality assessment

A quality assessment of included articles was undertaken using an adapted form of the National Heart, Lung, and Blood Institute (NHLBI) guidelines for cohort and case studies/series [19].

3. Results

A total of 2630 articles were found in the initial search; 2301 articles were screened based on title and abstract, from which 51 full texts were obtained. A final list of 13 articles was included in the review [16,20–31] (Fig. 1).

3.1. Median nerve (Table 2, Section 1)

Isolated median nerve (MN) injuries were infrequently described in the literature. Two case studies reported bilateral symptoms in men following long-distance rides [26,30]. One patient underwent an ultrasound and neurophysiology assessment, while the other did not undergo an initial assessment; however, both received cortisone injections as part of their management.

3.2. Ulnar nerve (Table 2, Section 2)

Nine studies described ulnar nerve (UN) injuries. These comprised 4 case reports [20,22,27,31] and 5
case series [21,23–25,28] with 18 cases involved (14 male and 4 female). Bilateral symptoms were described in three [20,23,24], whereas the others described unilateral cases [21–25,27,28,31]. Only two reported hand dominance [21,22]. Eight papers reported the precipitating event before the onset of symptoms; six described single long-distance rides of varying distances [20–23,25,28], of which one included a downhill ride [28]. One article reported multiple long-distance rides [24], and one documented that symptoms developed following a 3- to 4-h bicycle lesson [31]. The mechanism of injury was not described in one study [27]. In six out of nine studies, nerve conduction studies were used as an assessment [20–22,24,28,31], and no other modalities were described. One case series reported hand therapy as a mode of treatment [27]; again, no other intervention was described in the other cases.

3.3. Median and UN (Table 2, Section 3)

Two cohort studies evaluated M&UN symptoms in cyclists [16,29]. The first studied 25 riders, randomly selected out of 1800 who participated in a 600-mile cycling event [16]. Undertaking a mixture of strength and sensory assessments, the researchers found that up to 22% of mountain bikers and 25% of those riding road bikes had a reduction in grip strength. However, there were also concurrent UN symptoms with weakness in pincer strength in many of these cases. Only four subjects (16%) reported sensory changes in an MN distribution, but three had concurrent changes in a UN distribution. No further assessments (imaging or neurophysiology studies) were performed. A subsequent investigation was performed among 14 riders who participated in a week-long ride where
Table 2. Overall findings from the study with key findings and evidence levels based on the 2011 Oxford CEBM Evidence Levels of Evidence [18].

| Author                          | Study type          | Type of cyclist | Inciting event | Number/ gender | Nerves considered | Primary assessment | Other assessments | Results                                                                 | Interventions                        | Evidence level |
|--------------------------------|---------------------|-----------------|----------------|----------------|-------------------|--------------------|-------------------|--------------------------------------------------------------------------|---------------------------------------|----------------|
| **Section 1: Median nerve**    |                     |                 |                |                |                   |                    |                   |                                                                          |                                       |                |
| Braithwaite [26]               | Case report         | Road 100-mile   | 1 male         | Median         | Clinical          | None               |                   | Unilateral Clinical assessment Decreased pin-prick sensation in median nerve distribution of affected hand and weakness of thumb opposition. No obvious muscle wasting. Bilateral Clinical assessment Bilateral weakness of thumb abduction and opposition (MRC Grades 2–3), with no weakness of ulnar and radial innervated muscles. No muscle wasting, with sensation preserved. Neurophysiological testing Normal ulnar motor and sensory responses Markedly reduced compound muscle action potential (CMAP) amplitude from abductor pollicis brevis (APB) bilaterally, worse on the right side on motor studies. Distal latency to APB normal on the right, marginally prolonged on the left. Electromyography (EMG) showed florid fibrillation potentials and positive sharp waves in both APB muscles. There were no voluntary motor units detected. Ultrasound of median nerves at the wrist No focal enlargement of the median nerve suggestive of carpal tunnel syndrome (CTS). | Cortisone injection is given to relieve symptoms | 4               |
| Ali, Delamont, Jenkins, Bland, Mills [30] | Case report         | Road 300-km     | 1 male         | Median         | Clinical          | Neurophysiology and ultrasound |                   |                                                                          | None                                        | 4               |
| **Section 2: Ulnar Nerve**    |                     |                 |                |                |                   |                    |                   |                                                                          |                                       |                |
| Eckman, Perlstein, Altrocchi [20] | Case report         | Road 3000-mile   | 1 male         | Ulnar          | Clinical          | Nerve conduction studies |                   | Bilateral Right abductor digiti minimi (ADM) Distal latency: 5.9 ms (prolonged) Right 1st dorsal interosseous (DI) Distal latency: 6.9 ms (prolonged) Left ADM Distal latency: 4.4 ms (prolonged) Left 1st DI Distal latency: 4.7 ms (prolonged) | None                                       | 4               |
Noth, Dietz, Case Road Mauritz [21] series 400 -2000-km rides 3 male Ulnar and 1 female Clinical assessment Nerve conduction studies

Case 1
Unilateral
Conduction studies
Polyphasic action potential (AP) was recorded over the left hypothenar eminence (surface electrode), which was reduced to 500 μV (right hand 8.5 mV), and the distal latency was prolonged to 10.2 ms (righthand 3.2 ms).

Case 2
Unilateral
On presentation
Near-complete paresis of the right-hand muscles innervated by the ulnar nerve.
CMAP recorded from the hypothenar eminence
Almost completely abolished on the right hand
Normal on the left hand
Five weeks after presentation
Motor function had recovered slightly
Increased hypothenar compound AP (3.5 mV in contrast to 8 mV on the left hand).

Frontera [22] Case Road report Road 20-km ride 1 male Ulnar Clinical assessment Nerve conduction studies

Unilateral

Left ADM
Distal latency: 3.7 ms
Left 1st DI
Distal latency: 5.4 ms 4.0 ms (4 weeks after onset)

Case 1
Unilateral
Clinical assessment
Pure right ulnar motor paralysis with interosseous muscle wasting. No sensory impairment.
EMG
Isolated motor impairment involving all right intrinsic hand muscles innervated by the ulnar nerve.

Case 2
Bilateral
Clinical assessment
Left claw hand associated with paresthesia of both hands. Claw hand disappeared in 5 days.
EMG
Complete blockade of motor and sensory in the left hand and sensory blockade in the right.

Case 3
Bilateral
Clinical assessment
Paresthesia of both hands with motor disturbances mainly in the left hand.

(continued on next page)
| Author         | Study type | Type of cyclist | Inciting event | Number/Gender | Nerves considered | Primary assessment | Other assessments                  | Results | Interventions | Evidence level |
|---------------|------------|-----------------|----------------|---------------|------------------|-------------------|-------------------------------|---------|---------------|----------------|
| Hankey, Gub-  | Case series | Road            | Daily cycling, up to 2–4 h per day | 1 male and 1 female | Ulnar            | Clinical assessment | Nerve conduction studies | Case 1 | Bilateral | 4 |
| bay [24]      |            |                 |                |               |                  |                   |                               |         |               |                |
|               |            |                 |                |               |                  |                   | Distal motor latency: 5.2 ms (prolonged) | EMG: Denervation |                   |                |
|               |            |                 |                |               |                  |                   | Left ADM |                             |                |
|               |            |                 |                |               |                  |                   | Distal motor latency: 4.3 ms (borderline) | EMG: Denervation | Right 1st DI |                |
|               |            |                 |                |               |                  |                   | Case 2 | Unilateral |                |
|               |            |                 |                |               |                  |                   | Right ADM |                             |                |
|               |            |                 |                |               |                  |                   | Distal motor latency: 4.8 ms (prolonged) | EMG: Denervation | Right 1st DI |                |
|               |            |                 |                |               |                  |                   | Left ADM |                             |                |
|               |            |                 |                |               |                  |                   | Distal motor latency: 7.8 ms (prolonged) | EMG: Denervation | Right adductor pollicis |                |
|               |            |                 |                |               |                  |                   | Case 1 | Unilateral |                |
|               |            |                 |                |               |                  |                   | Left hand |                             |                |
| Maimaris,     | Case series | Mountain and road | 120–195 km rides | 2 male | Ulnar | Clinical assessment | None | Case 1 |                |
| Zadeh [25]    |            |                 |                |               |                  |                   | Unilateral |                             |                |
|               |            |                 |                |               |                  |                   | Left hand |                             |                |
|               |            |                 |                |               |                  |                   | Mild clawing of little finger | Marked weakness in ADM | Weakness in abduction and adduction of all fingers | Positive Froment's sign | Right hand |                |
|               |            |                 |                |               |                  |                   | Case 2 | Unilateral |                |
|               |            |                 |                |               |                  |                   | Left hand |                             |                |
|               |            |                 |                |               |                  |                   | Diminished pin-prick sensation in the little finger | Decreased power of abduction and adduction on the little finger | Froment's sign mildly positive | Right hand |                |
| Brandsma [27] | Case report | Road            | Not stated | 1 male | Ulnar | Clinical assessment | None | Case 1 | Hand therapy and evaluation |                |
|               |            |                 |                |               |                  |                   | Unilateral |                             |                |
|               |            |                 |                |               |                  |                   | Clinical assessment | Paralysis of the intrinsic ulnar muscles with the development of a claw hand bilaterally |                |                |
Section 3: Median and Ulnar Nerve

Sensation preserved in the right hand
Right fist dorsal interosseus (FDI)
Distal latency: 14.1 ms (prolonged, N: ≤42 ms) Low amplitude of compound muscle action potential (CMAP)
Right abductor digiti minimi (ADM)
Conduction studies normal
Case 2
Unilateral
Sensation preserved in both hands
Left FDI
Distal latency: 5.4 ms
Reduction of CMAP amplitude (1.2 mV) with denervation changes
Left ADM
Distal latency: 3.0 ms (normal: < 3.3 ms) Normal CMAP amplitude (9.0 mV)

Sensation preserved in both hands. Moderate weakness and atrophy of left ulnar intrinsic hand muscles, except left ADM.
Left FDI
Distal latency: 5.6 ms (prolonged)
Slight reduction of amplitude (3.2 mV) with denervation changes
Left ADM
Distal latency: 3.0 ms (normal) Normal CMAP amplitude (18.1 mV)

(continued on next page)
| Author                        | Study type of cyclist | Inciting event | Number / Nerves considered | Primary assessment                  | Other assessments | Results                                                                 | Interventions | Evidence level |
|-------------------------------|-----------------------|----------------|----------------------------|--------------------------------------|-------------------|-------------------------------------------------------------------------|---------------|----------------|
| Patterson, Jagiegers, Boyer [16] | Cohort16 road 600-km ride and 9 mountain | 13 male and 12 female | Ulnar and median | Clinical assessment for motor and sensory changes | None | Motor symptoms<br>Decrease in grip strength<br>Mountain bikers (M): 22.0%, road bikers (R): 25.0%<br>Decrease in pinch strength<br>M: 38.9%, R: 31.5%<br>Positive resisted abduction test<br>M: 16.7%, R: 25.0%<br>Froment's sign<br>M: 16.7%, R: 12.5%<br>Sensory symptoms<br>Tinel's sign<br>M: 16.7%, R: 3.1%<br>Phalen's sign<br>M: 5.6%, R: 3.1%<br>Elbow provocative test<br>M: 5.6%, R: 3.1%<br>Decreased sensation to distal 5th finger<br>M: 33.0%, R: 3.1%<br>Distal motor latencies of the deep branch of the ulnar nerve to the FDI were prolonged after the event (p < 0.05). Three subjects had CTS before that worsened after the event, and one developed CTS changes in the median nerve after the event. | N/A | 3 |
| Akuthota, Plastaras, Lindberg, Tobey, Press, Garvan [29] | Cohort420-mile tour | 7 female and 7 male | Ulnar and median | Nerve conduction studies | None |  |  | 3 |
70 miles were covered daily [29]. Using an electrophysiological assessment of the hands, they found that three subjects had changes consistent with carpal tunnel syndrome pre-ride, which worsened after their participation. One rider developed these changes de novo following the event.

3.4. Quality assessment

Based on the NHLBI [19] guidelines, each of the case studies/series included in the review scored 8/12 (Table 3), while the cohort studies scored 7/11 (Table 4).

4. Discussion

This review yielded two case studies focusing on the MN [26,30], nine case studies/series on the UN [20–25,27,28,31], and two cohort studies [16,29] focused on the M&UN. In both articles considering the MN, preexisting pathologies were suspected, and due to protracted symptoms following presentation that were not solved with conservative management, a cortisone injection was required.

The two cohort studies investigating M&UN injuries examined the prevalence in road and mountain bikers [16,29]. The first considered neurophysiological changes in cyclists’ hands and found that conduction was impaired in the first dorsal interossei (FDI) and the abductor digiti minimi (ADM) after the ride. At the same time, several subjects had MN changes.

Although neurophysiology was reported in most articles, ultrasound was used to evaluate the nerves more comprehensively [32–34]. Indeed, only one case report documented the use of ultrasound imaging when assessing the MN [30], leading to the suspicion that chronic changes, in keeping with carpal tunnel syndrome, had been present for some time. Typically, when nerves are examined, they can be assessed at the site of compression, for flattening or pinching of the nerve, and more proximally, where there is swelling suggestive of nerve compression [35]. In the hand, the UN can be traced from Guyon’s canal to its deep and superficial divisions. Measurements and typical pathological changes such as the “notch sign” can help assess and monitor the nerve [36]. As ultrasound imaging resolution improves, it may be possible to assess the nerve glide in a longitudinal plane to identify tethering areas from the compression pathology. Presently, ultrasound is more commonly used to guide treatments around nerves that have been compressed and are causing pain [37]. Thus, ultrasound can improve symptoms and allow subjects to return to normal activities, as in case reports of isolated MN compression [26,30]. However, ultrasound may have a role in screening and tracking the progression of nerve changes in cyclists to identify if and when further assessment is needed. Such progression tracking has been effective in other nerve-related [38] and muscle-related pathologies [39].

The classical description of a “handlebar palsy” [40] involves the UN and its deep branches distal to Guyon’s canal [41]. It is associated with sensory, motor, and coordination aberrations in the hand that can manifest during or several days after the ride. Most studies of this phenomenon were case reports [20,22,27,31] or case series [21,23–25,28]. The subjects mostly presented motor weakness in the FDI or ADM following prolonged compression during riding. Most of the subjects were experienced road-bike riders, with only two articles reporting this phenomenon in mountain bikers [25,28] and one in a novice cyclist [31]. Two articles also described this injury in semi-professional or competitive cyclists [22,28].

Rauch et al. (2016) [42] examined the UN in relation to the hamate in various riding positions using magnetic resonance imaging. They found that with the wrist extended or in ulnar deviation, the nerve was closer to the hamate, representing the common handlebar position adopted by riders. However, owing to the non-dynamic nature of MRI scanning and the cost for the patient, this would not be considered a first-line tool and might only be required with atypical symptoms.

During the ride, pressure on the hands to support the rider’s body weight and subsequent compression of the nerves appears to be the underlying trigger in most cases, particularly during a long ride. Indeed, compression is recognized as a risk factor for acute and chronic neuropathies [43] and has also been reported in occupationally induced nerve injuries such as carpal tunnel syndrome [44,45]. The typical forward riding position, particularly in road cycling, means that handlebar compression can vary according to the gripping style of the cyclist and whether they use gloves. While road cyclists appear to be most commonly affected at the wrist, triathletes who place the load on the forearms suffer compression neuropathies at the elbow [46].

Therefore, two interventions are proposed to support the cycling community. The first is incorporating neural protection and preservation among cyclists through education and training to alleviate potential problems in the future. As part of this process, it is important to undertake further research with experts in bicycle biomechanics to investigate different grip types [47].
| Author | Was the study question or objective clearly stated? | Was the study population clearly and fully described, including a case definition? | Were the cases consecutive? | Were the subjects comparable? | Was the intervention clearly described? | Were the outcome measures clearly defined, valid, reliable, and implemented consistently across all study participants? | Was the length of follow-up adequate? | Were the statistical methods well described? | Were the results well described? | Score |
|--------|--------------------------------------------------|-----------------------------------------------------------------|----------------------------|-----------------------------|----------------------------------------|------------------------------------------------------------------------------------------------|------------------|---------------------------------------------|---------------------------------------------|-------|
| Braithwaite [26] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Ali, Delamont, Jenkins, Bland, Mills [30] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Eckman, Perlstein, Altrocchi [20] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Noth, Dietz, Mauritz [21] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Frontera [22] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Haloua, Collin, Coudeyre [23] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Hankey, Gubbay [24] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Maimaris, Zadeh [25] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Brandsma [27] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Capitani, Beer [28] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
| Selçuk, Kursatan, Yildirim, Değirmenci, Akyüz [31] | Yes | Yes | No | Yes | No | Yes | No | No | Yes | 8 |
Table 4. Cohort study quality assessment using the NHLBI guidelines for cohort studies [19]. (Q1: Was the research question or objective in this paper clearly stated? Q2: Was the study population clearly specified and defined? Q3: Was the participation rate of eligible persons at least 50%? Q4: Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for the study prespecified and applied uniformly to all participants? Q5: Was a sample size justification, power description, or variance and effect estimates provided? Q6: For the analyses in this paper, were the exposure(s) of interest measured before the outcome(s) being measured? Q7: Was the time frame sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? Q8: For exposures that can vary in amount or level, did the study examine different levels of exposure as related to the outcome (e.g., categories of exposure or exposure measured as a continuous variable)? Q9: Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? Q10: Was the outcome(s) assessed more than once over time? Q11: Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? Q12: Were the outcome assessors blinded to the exposure status of participants? Q13: Was loss to follow-up after baseline 20% or less? Q14: Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?)

| Author | Q1. | Q2. | Q3. | Q4. | Q5. | Q6. | Q7. | Q8. | Q9. | Q10. | Q11. | Q12. | Q13. | Q14. | Score |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Patterson, Jaggars, Boyer [16] | Yes | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | 7 |
| Akuthota, Plastaras, Lindberg, Tobey, Press, Garvan [29] | Yes | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | 7 |

design, seat height [48], stem length [9], and the use of gloves [47,49], all of which influence weight distribution on the hands. Equally, cycling ergonomics and core muscle training [50] to ensure maintenance of posture should be included more widely in educational resources.

As a further intervention, a screening program for cyclists is proposed, incorporating self-administered questionnaires like the Boston Carpal Tunnel Questionnaire [51], which has been investigated as a potential screening tool for carpal tunnel syndrome in a potentially high-risk cohort [52]. Should symptoms be identified, referral to a specialist for further assessment and study can be recommended.

5. Conclusion

Given the rising popularity of cycling internationally, healthcare professionals and cyclists must work together to raise awareness of median and ulnar neuropathies among this active population. Preventive measures, prompt diagnosis, and treatment can potentially limit the morbidity associated with these pathologies. This evaluation highlights the need for further work, particularly when screening cyclists. Hopefully, this work will enable positive symptoms to be identified early rather than attributed to being part of the cycling experience.

Conflict of interest

The authors received no financial aid for this study, and the authors alone are responsible for the content and writing of the article.

References

[1] Elman L, McCluskey L. Occupational and sport related traumatic neuropathy. Neurol 2004;10:82–96.

[2] Lorei MP, Hershman EB. Peripheral nerve injuries in athletes: treatment and prevention. Sports Med 1993;16:130–47.

[3] Avbulsum I. Walking and cycling statistics, England: 2018. UK. Department for Transport; 2019. p. 1–15.

[4] McKenzie B. Modes less traveled—bicycling and working to walk in the United States: 2008−2012. USA: United States Census Bureau; 2014. p. 1–18.

[5] Abdullah Z. One in four Singapore households owns bicycles, politics news & top stories. Singapore: Straits Times; 2018.

[6] Beck B, Stevenson M, Newstead S, Cameron P, Judson R, Edwards ER, et al. Bicycling crash characteristics: an in-depth crash investigation study. Accid Anal Prev 2016;96:219–27.

[7] Ansari M, Nourian R, Khodaee M. Mountain biking injuries. Curr Sports Med Rep 2017;16:404–12.

[8] GR J, Broker JP, Ryan MM. The biomechanics of cycling. Exerc Sci Rev 1991;19:127–70.

[9] Swart J, Holliday W. Cycling biomechanics optimization—the (R) evolution of bicycle fitting. Curr Sports Med Rep 2019;18:490–6.

[10] Chavarrias M, Carlos-Vivas J, Collado-Mateo D, Perez-Gomez J. Health benefits of indoor cycling: a systematic review. Medicina 2019;55:1–14.

[11] Oja P, Titze S, Bauman A, Dr Geus B, Krenn P, Reger-Nash B, et al. Health benefits of cycling: a systematic review. Scand J Med Sci Sports 2011;21:496–509.

[12] Panis LI. Cycling: health benefits and risks. Environ Health Perspect 2011;119:a114.

[13] Cherington M. Hazards of bicycling: from handlebars to lightning. Semin Neurol 2000;20:247–53.

[14] Andersen KV, Bovim G. Impotence and nerve entrapment in long distance amateur cyclists. Acta Neurol Scand 1997;95:233–40.

[15] Brown CK, Stainsby B, Sovak G. Guyon canal syndrome: lack of management in a case of unresolved handlebar palsy. J Can Chiropr Assoc 2014;58:413–20.

[16] Patterson JMM, Jaggars MM, Boyer MI. Ulnar and median nerve palsy in long-distance cyclists: a prospective study. Am J Sports Med 2003;31:585–9.

[17] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:1–6.

[18] Howick J, Chalmers I, Glasziou P, Greenhalgh C, Liberati A, Moschetti I, et al. The 2011 Oxford CEBM evidence levels of evidence (introductory document). Oxford Centre for Evidence-Based Medicine; 2011. Available from: http://www.cebm.net/index.asp?o=5653. [Accessed 4 June 2020].

[19] NHLBI. Quality assessment tool for observational cross-sectional and case series studies. study quality assessment tools web site. National Health, Lung and Blood Institute; 2014.
Available from: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools. [Accessed 4 June 2020].

[20] Eckman PB, Perlstein G, Altrocchi PH. Ulnar neuropathy in bicycle riders. Arch Neurol 1975;32:130–1.

[21] Noth J, Dietz V, Mauritz KH. Cyclist's palsy: neurological and EMG study in 4 cases with distal ulnar lesions. J Neurol Sci 1980;47:111–6.

[22] Frontera WR. Case report cyclist's palsy: clinical and electrodiagnostic findings. BJSM 1983;17:91–3.

[23] Haloua JP, Collin JP, Coudeyre L. Paralysis of the ulnar nerve in cyclists. Ann Chir Main Memb Super 1987;6:282–7.

[24] Hankey GJ, Gubbay SS. Compressive mononeuropathy of the deep palmar branch of the ulnar nerve in cyclists. J Neurol Neurosurg Psychiatry 1988;51:1588–90.

[25] Maimaris C, Zadeh HG. Ulnar nerve compression in the cyclist's hand - two case reports and review of the literature. BJSM 1990;24:245–6.

[26] Braithwaite IJ. Bilateral median nerve palsy in a cyclist. BJSM 1990;24:257–8.

[27] Brandsma JW. Manual muscle strength testing and dynamic Extraneural findings during peripheral nerve ultrasound: prevalence and further assessment. Muscle Nerve 2013;48: 65–9.

[28] Capitani D, Beer S. Handlebar palsy - a compression syndrome of the deep terminal (motor) branch of the ulnar nerve in bicycling. J Hand Ther 1995;8:191–4.

[29] Akuthota V, Plastaras C, Lindberg K, Tobey J, Press J, Garvan C. The effect of long-distance bicycling on ulnar and median nerves: an electrophysiologic evaluation of cyclist palsy. Am J Sports Med 2005;33:1224–30.

[30] Ali E, Delamont RS, Jenkins D, Bland JDP, Mills KR. Bilateral recurrent motor branch of median nerve neuropathy following long-distance cycling. Clin Neurophysiol 2013;124: 1258–60.

[31] Selçuk B, Kurtaran A, Yiildirim O, Değirmenci İ, Akyüz M. Cyclist's neuropathy. Neurosurg Q 2015;25:337–40.

[32] Arnold WD, Elsheikh BH. Entrapment neuropathies. Neurol Clin 2013;31:405–24.

[33] Park CY, Kwon DR, Seok JI, Park DS, Cho HK. Usefulness of ultrasound assessment of median nerve mobility in carpal tunnel syndrome. Acta Radiol 2018;59:1494–9.

[34] Bignotti B, Zaottini F, Airaldi S, Martinoli C, Tagliafico A. Extraneural findings during peripheral nerve ultrasound: prevalence and further assessment. Muscle Nerve 2018;57: 65–9.

[35] Cartwright MS, Walker FO. Neuromuscular ultrasound in common entrapment neuropathies. Muscle Nerve 2013;48:696–704.

[36] Peck E, Strakowski JA. Ultrasound evaluation of focal neuropathies in athletes: a clinically-focused review. BJSM 2015; 49:166–75.

[37] Nwawka OK, Miller TT. Ultrasound-guided peripheral nerve injection techniques. AJR Am J Roentgenol 2016;207:507–16.

[38] Razali SNO, Arumugam T, Yuki N, Rozalli FI, Goh KJ, Shahrizaila N. Serial peripheral nerve ultrasound in Guillain-Barre syndrome. Clin Neurophysiol 2016;127:1652–6.

[39] Bright JM, Fields KB, Draper R. Ultrasound diagnosis of calf injuries. Sport Health 2017;9:352–5.

[40] Burke ER. Ulnar neuropathy in bicyclists. Phys Sportsmed 1981;9:52–6.

[41] Brubacher JW, Leversedge FJ. Ulnar neuropathy in cyclists. Hand Clin 2017;33:199–205.

[42] Rauch A, Teixeira PAG, Gillet R, Perez M, Clerc-Urmes I, Lombard C, et al. Analysis of the position of the branches of the ulnar nerve in Guyon's canal using high-resolution MRI in positions adopted by cyclists. Surg Radiol Anat 2016;38: 793–9.

[43] Tang DT, Barbour JR, Daveidge KM, Yee A, Mackinnon SE. Nerve entrapment: update. Plast Reconstr Surg 2015;135: 199e–215e.

[44] Koskimies K, Farrkila M, Pyykko I, Jantti V, Aatola S, Starck J, et al. Carpal tunnel syndrome in vibration disease. Br J Ind Med 1990;47:411–6.

[45] Monsell FP, Tillman RM. Shearer's wrist: the carpal tunnel syndrome as an occupational disease in professional sheep shearers. Br J Ind Med 1992;49:594–5.

[46] Bales J, Bales K, Baugh L, Tokish J. Evaluation for ulnar neuropathy at the elbow in ironman triathletes - physical examination and electrodiagnostic evidence. Clin J Sport Med 2012;22:126–31.

[47] Slane J, Timmerman M, Ploeg HL, Thelen DG. The influence of glove and hand position on pressure over the ulnar nerve during cycling. Clin Biomech 2011;26:642–8.

[48] Bini R, Hume PA, Croll JL. Effects of bicycle saddle height on knee injury risk and cycling performance. Sports Med 2011; 41:463–76.

[49] Bush K, Meredith D, Densey D. Acute hand and wrist injuries sustained during recreational mountain biking: a prospective study. Hand 2013;8:397–400.

[50] Abt JP, Smolgia JM, Brick MJ, Jolly JT, Lephart SM, Fu FH. Relationship between cycling mechanics and core stability. J Strength Cond Res 2007;21:1300–4.

[51] PLoS. Boston carpal tunnel questionnaire. Available from: https://journals.plos.org/plosone/article/file?id=info:doi/10.1371/journal.pone.0129918.s002&type=supplementary. [Accessed 5 June 2020].

[52] Sirisena D, Lim I, Sim SH-S, Tong P-Y, Rajaratnam V. Can the Boston carpal tunnel syndrome questionnaire be used as a screening tool among a potentially high-risk population in Singapore? JHAM 2020:1–9.