厚生労働行政推進調査事業費補助金
（健康安全・危機管理対策総合研究事業）

『新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

令和３年度　総括研究報告書

研究代表者　横堀　將司
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令和４（２０２２）年３月

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Ⅰ．総括研究報告書

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研究要旨：

目的：毎夏の熱中症の発生は発熱性疾患の新型コロナウイルス感染症（COVID-19）の蔓延との重なりにより、救急医療への負担を増大させる。本研究は、新しい生活様式、ウイズコロナの中で熱中症をいかに安全に予防すべきか、広く国民に正確な情報を提供することを目的とする。

研究方法：主として下記の研究を行う。

①新しい生活様式下での熱中症発症のリスク関連因子の評価を行うため、医療機関で熱中症と診断された対象の情報を収集する。また対象の一般診療情報を解析し、病態や治療の現状を把握したうえで、発生の予防に向けた地域医療へのアプローチを検討する。
研究の種類・デザイン：前向き観察研究
方法： 2021年6月1日（予定）から9月30日までの期間に、日本救急医学会に登録された医療機関（日本救急医学会指導医施設約140施設）で熱中症と診断された患者。
診療録から、年齢、性別、来院方法、発生状況、現場でのバイタルサイン、既往歴、生活歴、来院時の所見（身体所見、採血結果など）、発生要因、治療法、転帰に関する情報を匿名化してwebにて登録し、その後に集計・解析を行う。また、同時に別個のマスク着用の有無に関する症例抽出を行い、マスク着用の来院時深部体温や熱中症重症度、バイタルサインや血液データとの関連性を検討する。
②熱中症予防ツールの開発と継続的データ収集：日本救急医学会の熱中症レジストリデータより開発された熱中症重症度スコアリング（J-ERATO score）や、日本救急医学会熱中症分類の症状を基にした熱中症診断アプリの開発を行い、広く全国の救急医療機関、救急隊、介護従事者やヘルスケアプロバイダ、市民に周知させる。また、熱中症予防ツールを使用した市民や医療従事者に追加のアンケートを施行し、更なる改善を図る。

結果と考察：

①新しい生活様式における熱中症発症のリスク評価：Heat stroke STUDY2020-21：全国138施設の協力を得て、2021年は659例のデータを収集した。なお、同じコロナ禍であった2020年の登録は1081例であった。今年度は8月後半の冷夏の為もあり、患者発生が少なかった可能性がある。一方、死亡率は8.4%→9.1%と微増していた。また、Active cooling（冷却デバイスや冷水浸漬を用いた積極的な冷却）施行率は33.5%→22.3%に低下していた。マスク着用下の発症は53例（18.2%）→110例（27.9%）と増加傾向が見られた。ちなみに発症形態は屋外発症が増加していた（523例（49.3%）→336例（53.2%））。なおマスク着用の有無で死亡率や来院時体温に差は見られなかった。
②熱中症予防ツールの開発と継続的データ収集
ダウンロード数は6月1日から10月31日までの間に1,219件に及び、実際に患者発生の際に使用された件数は245件（平均年齢41.7歳）であった。全体の66.5%の患者がマスクを着用していたものの、マスクの有無と体温に直接的な関連は見られないことが明らかになった。また、マスク着用の有無と重症度の差異は見られなかった。学校教職員、ライフセーバー、救命救急士学生などのヘルスケアプロバイダー（HCP）や、一般市民を対象としたアプリケーションの周知とアンケート調査も行ったが。HCP、一般市民ともに、熱中症診断補助スケールとアプリの使用について好意的な意見が見られた。一方、一般市民において「なまあくび」や「集中力・判断力の低下」は評価が難しいと回答が多かった。

結論：新しい生活様式による環境因子の変化が、熱中症の発症にどのように影響を与えるか検討し、熱中症と感染症予防の両立の評価を行うことができた。とくに、アプリケーションは現場で使用でき、入力が簡便であることが示唆された。ヘルスケア従事者と一般市民の選択方法、収縮期血圧の入力方法、一般市民の症状の選択について改善をする必要がある。

研究分担者
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A．研究目的

わが国における熱中症は高齢者かつ非労作性熱中症が多いことが特徴であり、環境因子が発症の要因の一つとされている。毎夏、熱中症患者の増加に加え、同様に発熱性疾患の新型コロナウイルス感染症（COVID-19）の蔓延により、更なる救急医療への負担増大が危惧されている。事態の完全な収束には年単位の長期間を要するとの試算もあり、パンデミック下の熱中症患者の増加は、さらに国民や地域救急医療体制に大きな影響を及ぼすことが懸念される。

新型コロナウイルス感染症の蔓延への対策のための新しい生活様式においては、環境因子として室内換気に伴う温度や湿度の上昇、マスクなどの感染防護具の着用など、全ての年齢層に影響する要因が含まれている。さらに外出等の減少に伴う運動量の低下から、暑熱順化の遅れや社会的孤立による熱中症発見の遅れなど、熱中症患者の増加が危惧されている。

しかし、いわゆるウイズコロナの新しい生活様式の環境下においては、熱中症予防に関する情報が依然不十分であり、学術的論拠が限られている。パンデミック下でのCOVID-19 蔓延予防と熱中症予防の両立において、混乱が生じる可能性も危惧されている。

我々は、令和２年度厚生労働行政推進調査事業費補助（厚生労働科学特別研究事業）の支援のもとコロナ禍における重症熱中症の全国調査（1032例）を施行した。これによると、コロナウイルス関連検査329例中5例の患者がコロナウイルス陽性との診断となっていたことから、熱中症とコロナウイルス感染を早期に分別すべき要因を明確にすべきであると考えた。また、熱中症患者の40名にマスクの着用が確認された。ゆえコロナウイルス感染予防と熱中症予防の科学的方略の確立は必須である。

新しい生活様式、ウイズコロナの中で熱中症をいかに安全に予防すべきか、科学的予防法の確立を行い、広く国民に正確な情報を提供することを本研究の目的とする。

B．研究方法

①新しい生活様式における熱中症発症のリスク評価（研究代表者：横堀、研究分担者：神田）

新しい生活様式下での熱中症発症のリスク関連因子の評価を行うため、医療機関で熱中症と診断された対象の情報を収集する。また対象の一般診療情報を解析し、病態や治療の現状を把握し、発生の予防に向けた地域医療へのアプローチを検討する。

・研究の種類・デザイン：前向き観察研究

・方法： 2021年6月1日（予定）から9月30日までの期間に、日本救急医学会に登録された医療機関（日本救急医学会指導医施設約140施設）で熱中症と診断された患者を対象にする。（例年の熱中症発生数・レジストリ患者数からおよそ2000名の情報収集が推測される。）

横堀が研究代表者の委員長を務める日本救急医学会熱中症に関する委員会を研究の主管とし、対象期間に「熱中症に関する全国調査」の調査用紙に加え、さらに別個に発症患者のマスク着用の有無及びCOVID-19の診断の有無(PCR検査と抗原検査）を問う質問紙を用い、全国的にマスク着用およびCOVID-19と熱中症発症とのリスク関連を調査する。

患者の一般診療情報とともに解析して、病態や治療の現状を把握し、発生の予防に向けた地域医療へのアプローチを検討するものである。診療録から、年齢、性別、来院方法、発生状況、現場でのバイタルサイン、既往歴、生活歴、来院時の所見（身体所見、採血結果など）、発生要因、治療法、転帰に関する情報を匿名化してwebで登録し、その後に集計・解析を行なう。また、同時に別個のマスク着用の有無に関する症例抽出を行い、マスク着用の来院時深部体温や熱中症重症度、バイタルサインや血液データと

の関連性を検討する。また熱中症と疑われ来院された患者のうちCOVID-19陽性患者(PCR陽性例)の存在を確認し、発熱・高体温を大症状とし、鑑別が困難であるCOVID-19が熱中症患者のなかにいかほど含まれるか、潜在的併存率についても確認する。

インフォームド・コンセント（ＩＣ）を受ける手続き：

学会からの研究資料に基づき、包括的に同意を取得し患者個人からの承諾は取得しない。研究への協力を希望されない患者に対しては、非協力権を保障する。

個人情報の取り扱い

登録に関しては無記名であり、個人を識別できる情報（氏名、住所、生年月日、電話番号）は入力されず、連結不可能である。

②熱中症予防ツールの開発と継続的データ収集（研究分担者：林田、阪本、鈴木）

従来、研究分担者の林田を中心として、日本救急医学会の熱中症レジストリデータより熱中症重症度スコアリング（J-ERATO score）の開発がなされてきた。本スコアリングをスマートフォンでのアプリケーション化を行い、広く全国の救急医療機関、救急隊、介護従事者に周知させる。

これにより、更なる熱中症を疑うべき患者の発生を認知し、全国的にデータ収集を行う。同時に、熱中症が疑われる患者に受診の早期啓発を行う。

また、熱中症予防ツールを使用した市民や医療従事者に追加のアンケートを施行し、更なる改善を図る。

（倫理面への配慮）

個人情報の取り扱い

登録に関しては無記名であり、個人を識別できる情報（氏名、住所、生年月日、電話番号）は入力されず、連結不可能である。

なお、本研究は日本医科大学付属病院および日本医科大学倫理委員会にて受審を行い、承認を得ている。（日本医科大学付属病院倫理委員会　B-2020-134　日本医科大学倫理委員会A-2021-056）

Ｃ．研究結果

①新しい生活様式における熱中症発症のリスク評価（研究代表者：横堀、研究分担者：神田）

Heat stroke STUDY2020-21

全国138施設の協力を得て、2021年は659例のデータを収集した。なお、同じコロナ禍であった2020年の登録は1081例であり、今年度は8月後半の冷夏の為もあり、患者発生が少なかった可能性がある。一方、死亡率は8.4%→9.1%と微増していた。

また、Active cooling（冷却デバイスや冷水浸漬を用いた積極的な冷却）施行率は33.5%→２2.3%に低下していた。（表１）。

表1		2020年		2021年	
症例数		1081例	割合	659例	割合
院内死亡	死亡	81	8.4	50	9.1
	生存退院	888	91.6	499	90.9
	Unknown	112		110	
退院時	3-6	329	34.0	184	33.6
m-Rankin Scale	0-2	638	66.0	364	66.4
	Unknown	114		111	
冷却法	Active Cooling	314	33.5	127	22.3
	点滴のみ	623	66.5	442	77.7
	Unknown	144		90	

マスク着用下の発症は53例（18.2%）→110例（27.9%）と増加傾向が見られた。ちなみに発症形態は屋外発症が増加していた。523例（49.3%）→336例（53.2）。なおマスク着用の有無で死亡率や来院時体温に差は見られなかった（表2）。

表2		マスク着用あり (n = 47)	着用なし (n = 199)	p
		n (%)	n (%)	
In-hospital deaths, n (%)		1 (2.2)	21 (11.6)	0.054
	Unknown	1	18	
Core temperature, Celsius (°C), n (%)				0.437
	> 42.0+	0 (0.0)	2 (2.3)	
	40.0–41.9	4 (22.2)	30 (34.1)	
	38.0–39.9	8 (44.4)	40 (45.5)	
	<38.0	6 (33.3)	16 (18.2)	
	Unknown	29	111	

②熱中症予防ツールの開発と継続的データ収集（研究分担者：林田、阪本、鈴木）

従来、研究分担者の林田を中心として、日本救急医学会の熱中症レジストリデータより熱中症重症度スコアリング（J-ERATO score）の開発がなされてきた。本スコアリングをスマートフ

ォンでのアプリケーション化を行い、広く全国の救急医療機関、救急隊、介護従事者に周知させた。

これにより、更なる熱中症を疑うべき患者の発生を認知し、全国的にデータ収集を行う。同時に、熱中症が疑われる患者に受診の早期啓発を行った。

②-1熱中症アプリケーションから取集したマスク着用のリスク評価

今年度作成した熱中症アプリケーションを2021年6月1日よりリリースした（図１）。リリースに関しては環境省の熱中症アラートに付加し、

図１：熱中症アプリケーションのリリース


日本救急医学会"熱中症スマホアプリ"開発

2021年6月15日 22:01

本格的な夏を迎える前に日本救急医学会は、一般の人も利用できる熱中症の重症度を判断するスマートフォンのアプリを開発したと発表しました。

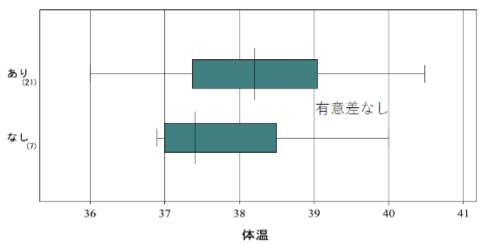
6月15日　日本テレビ　News 24

熱中症かも、そんなときは…日本救急医学会が診断アプリを公開　深刻さの判断手助け

7月17日　東京新聞　WEB

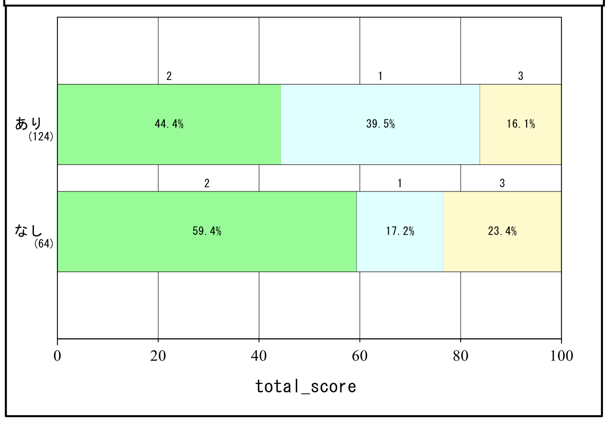
広く国民に周知させた。実際に、ダウンロード数は6月1日から10月31日までの間に1,219件に及び、実際に患者発生の際に使用された件数は245件（平均年齢41.7歳）であった。全体の66.5%の患者がマスクを着用していたものの、マスクの有無と体温に直接的な関連は見られないことが明らかになった(図２)。

図２　マスクの有無と発症時体温



また、マスク着用の有無と重症度の差異は見られなかった（p=0.08、下図マスクありなしと熱中症1-3度の関係：図３）

図3:　マスク着用の有無と熱中症の重症度の関係



②-２　学校教職員へのアンケート

学校教職員、ライフセーバー、救命救急士学生などのヘルスケアプロバイダや、一般市民を対象としたアプリケーションの周知とアンケート調査を行った。

期間：2021年8月6日から同9月30日

対象；学校教職員542名

方法：アプリケーションのダウンロードと使用に関する自由記載のアンケート調査

学校教職員に熱中症アプリを使用させ、その使用感を確認した。

結果：

自由記載のアンケートから以下の改善点を明確にした。

「日本語でのチェックと英語のチェックが混在していて分かりづらい」

「学校に小児用のマンシェットがないので血圧の確認は難しい」など、学校教職員　養護教師の立場からの意見を集約できた

②-２　ライフセーバーを対象としたアプリケーションの周知とアンケート調査

期間：2021年11月30日から同12月13日

対象；日本体育大学ライフセービング部

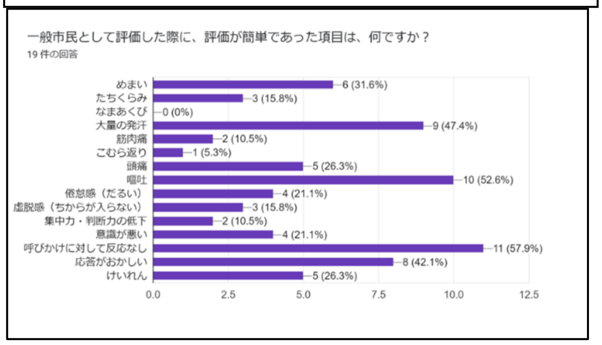
方法：アプリケーションのダウンロードと使用に関するアンケート調査

結果　19名全例から回答を得た。背景を表3に示す。

表３：回答者背景		N=19	%
年齢	10-19歳	5	26.3
	20-29歳	14	73.7
性別	男性	7	36.8
医療従事者		2	16.7
正確な体温が測定できる		12	63.2
正確な意識レベルが評価できる		6	31.6
正確な呼吸が評価できる		11	57.9
正確な血圧が評価できる		4	21.1
正確な脈拍が評価できる		11	57.9

「熱中症診断補助スケールは現場で使用できるか」という問いに対して、使えるが8名(42.1%)、まあまあ使える7名(36.8%)、どちらともいえないが4名(21.1%)であった。「熱中症診断補助スケールの使用は難しかったですか」という問いに対して、難しいが2名(10.5%)、やや難しいが3名(15.8%)、どちらともいえないが8名(42.1%)、まあまあ易しいが1名（5.3%）、易しいが5名(26.3%)であった。ヘルスケア従事者として評価した際に、「意識」が最も簡単(63.2%)で、「血圧」が最も難しい(63.2%)と回答があった。

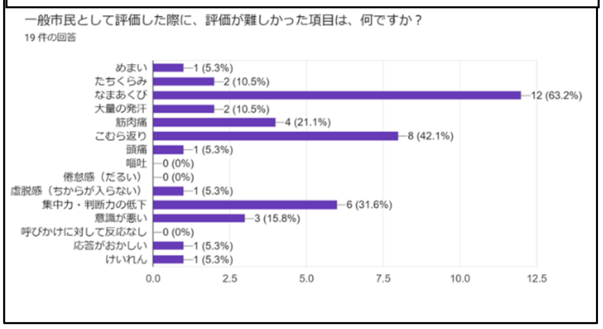
図4:一般市民として評価した際に、評価が簡単であった項目(複数回答可)



一般市民として評価した際に、「呼びかけに対して反応なし」が最も簡単（57.9%）で、「なまあくび」が最も難しい（63.2%）と回答があった（図4・５）。全ての評価をするまでに、1分以内が2名（10.5%）、1-3分以内が10名(52.6%)、3-5分以内が4名(21.1%)、5分以上が3名(15.8%)であった。

「ライフセーバーがアプリを使用する場合、どちらが使いやすいですか」という問いに対して、ヘルスケア従事者が5名(26.3%)、一般市民が14名(73.7%)であった。

図5:一般市民として評価した際に、評価が難しかった項目(複数回答可)



②-３　救急救命士学生を対象としたアプリケーションの周知とアンケート調査

期間：2021年11月30日から同12月13日

対象；日本体育大学救急医療サークル

方法：アプリケーションのダウンロードと使用に関するアンケート調査

結果

9名から回答を得た。回答者の背景を表４に示す。

表４：回答者背景		N=9	%
年齢	10-19歳	7	77.8
	20-29歳	2	22.2
性別	男性	9	100
正確な体温が測定できる		9	100
正確な意識レベルが評価できる		9	100
正確な呼吸が評価できる		8	88.9
正確な血圧が評価できる		7	77.8
正確な脈拍が評価できる		8	88.9

「熱中症診断補助スケールは現場で使用できるか」という問いに対して、使えるが8名(88.9%)、まあまあ使える1名(11.1%)であった。「熱中症診断補助スケールの使用は難しかったですか」

という問いに対して、やや難しいが2名(22.2%)、どちらともいえないが2名(22.2%)、まあまあ易しいが1名（11.1%）、易しいが4名(44.4%)であった。ヘルスケア従事者として評価した際に、「意識」が最も簡単(77.8%)で、「血圧」が最も難しい（77.8%）と回答があった。一般市民として評価した際に、「嘔吐」が最も簡単（55.6%）で、「なまあくび」が最も難しい（66.7%）と回答があった（図6・7）。全ての評価をするまでに、1分以内が1名（11.1%）、1-3分以内が8名(88.9%)であった。

「救急医療サークルの学生がアプリを使用する場合、どちらが使いやすいですか」という問いに対して、ヘルスケア従事者が8名(88.9%)、一般市民が1名(11.1%)であった。

②-４アプリケーション使用者に対するアンケート調査

期間：2021年11月30日から同12月13日

対象；熱中症アプリ使用経験者

方法：アンケート調査

結果：

アンケート回答者21名中12名が使用経験ありと回答した。背景を表５に示す。

表５：回答者背景		N=12	%
年齢	10-19歳	2	16.7
	20-29歳	1	8.3
	30-39歳	1	8.3
	40-49歳	4	33.3
	50-59歳	4	33.3
性別	男性	9	75
医療従事者		2	16.7
正確な体温が測定できる		9	75
正確な意識レベルが評価できる		8	66.7
正確な呼吸が評価できる		8	66.7
正確な血圧が評価できる		7	58.3
正確な脈拍が評価できる		6	50

熱中症診断補助スケールについて、使えないが1名(4.8%)、どちらともいえないが5名(23.8%)、まあまあ使えるが4名(19%)、使えるが2名(9.5%)であった。

使用した場所は、屋内が最も多く8名(38.1%)、屋外3名（14.3%）、救急車内1名(4.8%)であった（図6）。熱中症診断補助スケールの使用については、難しいが1名(4.8%)、どちらともいえないが2名(9.5%)、まあまあ易しいが5名(23.8%)、易しいが4名(19%)であった。

熱中症診断補助スケールの評価項目の中で「意識」が最も簡単(42%)で、「血圧」が最も難しい(58%)と回答があった。すべてを評価するまでの時間は、1分以内が3名(14.3%)、1-3分以内が5名(23.8%)、3-5分以内が3名(14.3%)、5分以上が1名(4.8%)であった。自由記載のアンケートから抽出した改善点として、「起動が遅い」、「退会機能がない」、「最初の登録がやりづらい」、「一般市民用に登録する方法が分かりにくい」「他の傷病の手当も確認できるとよい」があった。

D．考察

研究①新しい生活様式における熱中症発症のリスク評価

今回の結果では、積極的治療、いわゆるActive coolingの割合が低下していた。

日本救急医学会は関連4学会（日本救急医学会、日本臨床救急医学会、日本感染症学会、日本呼吸器学会）の治療ガイドラインとして、新型コロナウイルス感染症流行下における 熱中症対応の手引きを2020年7月に発出した。これには、エアロゾル発生の観点から、蒸散冷却法は避けるべきとの文言が追加されていたことも影響していると思われたが、実際の蒸散冷却の割合には変化がなかった。むしろ新型コロナ発生者数が2020年から2021年にかけて急激に増加していることから、救急医療への負荷がかかり、充分な治療ができなかった可能性も否定できない。

マスク着用下の熱中症患者が増加したのは、2021年に屋外の熱中症発症が増加していることも一因であると思われた。マスクを着用してい

るから熱中症になりやすいかという臨床的疑問については、依然明確にできない課題であるが、リアルワールドデータを引き続き収集する意義が明確になった。なお、今回の解析においては、マスク着用と深部体温や熱中症の重症度、転帰との関連はみられなかった。

研究②

熱中症予防ツールの開発と継続的データ収集本研究では、熱中症診断アプリケーションを用いたリアルワールドデータを解析した。
マスク着用の有無による体温の違いはなく、従来、私たちが基礎研究で得ることができた結果、すなわちマスク着用の有無は熱中症のリスクにならないことを現実のデータで示したものとなった。

コロナ禍におけるマスク着用の有無について危険性を指摘した論調は従来多かったが、本研究の結果から、マスク着用が熱中症の直接的な発症や重症化のリスクにはならないことが明確になった。今後、新しい生活様式による環境因子の変化が、熱中症の発症にどのように影響を与えるかをさらに検討し、マスク着用における熱中症発症の危険性の客観的評価を継続することで、日本救急医学会等の4学術団体が主導し作成した、「新型コロナウイルス感染症の流行を踏まえた熱中症予防に関する提言」および、「新型コロナウイルス感染症流行下における熱中症対応の手引き（医療従事者向け）」を改定する作業に反映させていきたい。

また、今回は熱中症予防ツールを広く普及させるべく、その使用感を調査するため、学校教職員、ライフセーバー、救急救命士養成課程の学生を対象に、アプリケーション使用に関するアンケート調査を行った。またアプリを使用した方を対象にアンケート調査を行った。その結果を基に以下の改善点を抽出した。

1)ヘルスケア従事者と一般市民の選択

アプリケーションでは。「操作をしているあなたは医療従事者・救急隊員などヘルスケア従事者ですか？一般市民ですか？」という問いがある。また「ヘルスケア従事者は、正確な体温、意識レベル、呼吸、血圧、脈拍が測定な者」と記載されている。そのため、一定頻度で観察をしているまたは業務として実施している立場の方は、どれか１つでも測定できれば、ヘルスケア従事者として認識した可能性がある。観察に対してできると回答している割合が多ければ多いほど、ヘルスケア従事者を選択する傾向にある。ヘルスケア従事者と一般市民の選択をどこで分けるかを検討する必要がある。

２）ヘルスケア従事者の「収縮期血圧」の入力について

血圧については、最も難しい評価項目として回答されていた。傷病者が小児であった場合、小児用の血圧計がない、アプリを使用する状況で血圧計がないなど血圧測定ができない状況がある。ヘルスケア従事者を選択した場合、収縮期血圧を入力しないと先の選択肢に進むことができず、血圧測定ができない場合の選択肢を検討する必要がある。

３）一般市民の症状の選択について

「なまあくび」や「集中力・判断力の低下」は評価が難しいと回答が多かった。呼びかけ反応のように判断できる方法が明確であれば、症状の観察がしやすい可能性がある。また、「こむら返り」は医療用語ではないが、言葉の意味を知らない場合は判断ができない。一般市民が使用するには、観察する方法と共にわかりやすい言葉にする必要がある。

Ｅ．結論

本研究により、新しい生活様式による環境因子の変化が熱中症の発症にどのように影響を与えるか検討し、熱中症と感染症予防の両立の評価を行うことができた。　熱中症患者のうち、マスクを装着していた患者の頻度を知ることで、マスク着用における熱中症発症の危険性を客観的に評価できた。

副次的に正確な熱中症診断や重症度評価のための診断デバイスの応用開発も展開することが

できた。とくに、アプリケーションは現場で使用でき、入力が簡便であることが示唆された。ヘルスケア従事者と一般市民の選択方法、収縮期血圧の入力方法、一般市民の症状の選択について改善をする必要がある。

F．健康危険情報

なし

G．研究発表

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2.　学会発表

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・神田潤，吉池昭一，朝見正宏，三宅康史. COVID-19流行下における冷却法（重症熱中症）の検討ー蒸散冷却法におけるエアロゾルの発生についてー（第19回日本臨床医学リスクマネジメント学会：2021/9/12長野）（資料5）

・神田潤. マスク着用時に発症した熱中症の特徴とエアロゾルを介した蒸散冷却のリスク（第49回日本救急医学会：2021/11/22東京）（資料6）

・Jun Kanda. Differences in heat stroke prevention between Japan and Southeast Asia (11th Asian Conference on Emergency Medicine (ACEM) 2021：2021/12/18 Hong Kong (China))（資料7）

H．知的財産権の出願・登録状況

（予定を含む。）

1. 特許取得

なし

2. 実用新案登録

なし

3. その他

なし

資料 1

RESEARCH ARTICLE

Association between active cooling and lower mortality among patients with heat stroke and heat exhaustion

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Abstract

Body cooling is recommended for patients with heat stroke and heat exhaustion. However, differences in the outcomes of patients who do or do not receive active cooling therapy have not been determined. The best available evidence supporting active cooling is based on a case series without comparison groups; thus, the effectiveness of this method in improving patient prognoses cannot be appropriately quantified. Therefore, we compared the outcomes of heat stroke patients receiving active cooling with those of patients receiving rehydration-only therapy. This prospective observational multicenter registry-based study of heat stroke and heat exhaustion patients was conducted in Japan from 2010 to 2019. The patients were stratified into the "severe" group or the "mild-to-moderate" group, per clinical findings on admission. After conducting multivariate logistic regression analyses, we compared the prognoses between patients who received "active cooling + rehydration" and patients who received "rehydration only," with in-hospital death as the endpoint. Sex, age, onset situation (i.e., exertional or non-exertional), core body temperature, liver damage, renal dysfunction, and disseminated intravascular coagulation were considered potential covariates. Among those who received active cooling and rehydration-only therapy, the in-hospital mortality rates were 21.5% and 35.5%, respectively, for severe patients (n = 231) and 3.9% and 5.7%, respectively, for mild-to-moderate patients (n = 578). Rehydration-only therapy was associated with a higher in-hospital mortality in patients with severe heat illness (adjusted odds ratio [aOR], 3.29; 95% confidence interval [CI], 1.21–8.90), whereas the cooling methods were not associated with lower in-hospital mortality in patients with mild-to-moderate heat illness (aOR, 2.22; 95% CI, 0.92–5.84). Active cooling was associated with lower in-hospital mortality only in the severe group. Our results indicated that active cooling should be recommended as an adjunct to rehydration-only therapy for patients with severe heat illness.

Competing interests: The authors have declared that no competing interests exist.

Introduction

Heat illnesses, caused by exposure to or exertion in hot environments, are a growing public health concern owing to climate change. Heat stroke and heat exhaustion are a severe form and a mild-to-moderate form of heat illnesses, respectively. In July 1995, Chicago, IL (USA) sustained a heat wave that resulted in more than 600 excess deaths and 3300 excess emergency department visits [1]. In France, more than 14 800 people died of a heat stroke caused by a heatwave in August 2003 [2]. Since 2010, an increasing number of heat stroke patients have been reported in various parts of the world [3–7].

In Japan, because of high temperatures and humidity in the summer, heat stroke and heat exhaustion occur more frequently among elderly people. More than 50,000 patients with heat illnesses are taken to hospitals each summer. On account of heat illnesses caused by the heat wave of 2018, 95,137 patients required hospital visits and 1677 patients died [8, 9]; most of these patients were older adults who were affected during daily activities [10].

Heat stroke is a life-threatening condition requiring prompt recognition and vigorous treatment [11]. Gaudio et al. [12] recommend active cooling to quickly reduce body temperature and fluid replacement to address dehydration. The best available evidence supporting active cooling is shown in a case series without comparison groups; thus, this case series alone could not appropriately quantify the effectiveness of this method in improving patient prognoses [1]. Various studies have reported improved symptoms and fewer patient fatalities after administering the following active cooling methods: cold-water immersion [13–17]; placing numerous ice-filled rubber bottles over the body [18] or covering the body with water-soaked fine gauze sheets [19]; use of fans [19], body-cooling units [20], water sprays [19, 21], and external cooling and cold-water gastric lavage [22]. The Japanese guidelines for heat stroke and heat exhaustion, created by the Japanese Association for Acute Medicine, recommend two active cooling methods in addition to evaporative methods: external convective cooling and internal gastric lavage and bladder irrigation [23]. The guidelines do not recommend using cold-water immersion, body-cooling units, intravascular ice cradles, and temperature management by extracorporeal membrane oxygenation because of safety concerns regarding older patients and those with disturbed consciousness or shock status.

Several controlled trials have shown that among healthy volunteers with exercise-induced hyperthermia, evaporative plus convective cooling or immersion in water baths at 2°C can reduce body temperature faster than other cooling methods [24, 25]. Comparisons to determine the effectiveness of various cooling methods among patients with heat illnesses are lacking.

In this study, we compared the prognosis of heat stroke and heat exhaustion patients treated with active cooling methods or with rehydration-only therapy by using data from a nationwide heat stroke and heat exhaustion registry database. We determined the therapeutic value of active cooling as an adjunct to rehydration-only therapy for the management of severe heat-related illness.

Materials and methods

Study settings

Japan has a temperate humid climate with four seasons. During the summer season from June to September, daytime maximum temperatures and relative humidity exceed 35°C (308.15 K) and 75%, respectively. The so-called unpleasant days, defined as a discomfort index ≥80, account for nearly 30 days in Tokyo [8]. In addition, Japan has the world's most aged society: individuals aged ≥65 years account for 28.6% of the population, as of 2020 [26]. Most heat stroke and heat exhaustion patients are therefore older adults. Greater frequencies of heat stroke and heat exhaustion cases are seen every year. The Japanese Association for Acute Medicine started the Heat stroke Study (HsS) in 2006 as a biennial nationwide multicenter registry of heat stroke and heat exhaustion patients. The data has been collected annually since 2017. Participating facilities are emergency centers capable of providing comprehensive emergency care 24 hours a day, 7 days a week, for all serious and multidisciplinary emergencies. In Japan, there are guidelines for treating heat stroke. Each facility selects a cooling method based on its available medical equipment, supplies, and human resources.

Study design

This study was a prospective observational multicenter registry-based study of hospitalized patients with heat stroke and heat exhaustion. We evaluated the prognoses of patients who received active cooling in hospital and patients who did not. The Ethical Review Board for Medical and Health Research at Teikyo University (Tokyo, Japan) approved the study protocol (approval numbers. 17-021-5 and 17-053-3). The study protocol was also approved by the ethical review boards of each participating institution. The requirement for informed consent was waived because of the retrospective study design and the use of anonymized data.

Data source

We obtained the following data at hospital admission from the HsS registry: age, sex, year of registration, core body temperature, consciousness, liver damage, renal dysfunction, and disseminated intravascular coagulation (DIC). We focused on the associations between cooling methods and patients' outcomes; therefore, we excluded the HsS data of 2006 and 2008 because they did not include this information.

The HsS data collection was conducted from July to September in the study years (i.e., 2010, 2012, 2014, and 2017–2019). All heat illness patients (i.e., hospitalized and non-hospitalized) were registered during 2010–2012, whereas only hospitalized patients were registered during 2014–2019. In each participating hospital, the emergency department physicians diagnosed heat illnesses, based on symptoms (e.g., high body temperature and signs of dehydration such as dizziness, myalgia, headache) and history of exposure to hot environments before the symptom onset [27, 28]. Patients with an infectious disease were excluded; i.e., we excluded cases diagnosed as infections because of the presence of bacteria in blood cultures or pneumonia on radiographs or computed tomography scans. The physicians collected the patient data from the medical records and registered them by using a web-based data collection system. Data were collected on variables such as symptom onset situation (e.g., sports, labor, or everyday life); parameters at hospital arrival such as vital signs, core body temperature (i.e., bladder or rectal temperature), and laboratory parameters (indicating liver, hepatic, and coagulation functions); cooling methods; and in-hospital deaths. Prognoses after discharge from the hospital emergency department were not investigated.

Study participants

The study participants were hospitalized patients diagnosed with heat stroke or heat exhaustion and registered in the HsS in 2010, 2012, 2014, 2017, 2018, and 2019. Of the 5739 registered patients, 3142 hospitalized patients with exceptionally low mortality risk; 560 patients with missing outcome or cooling methods data were excluded. Of the 2582 patients analyzed, 1773 patients with partially missing data underwent univariate analyses and 809 patients with complete data underwent multivariate analysis (Fig 1). We categorized the participants into the severe group (i.e., core body temperature, $\geq$40.0°C [313.15 K]; Glasgow Coma Scale [GCS]

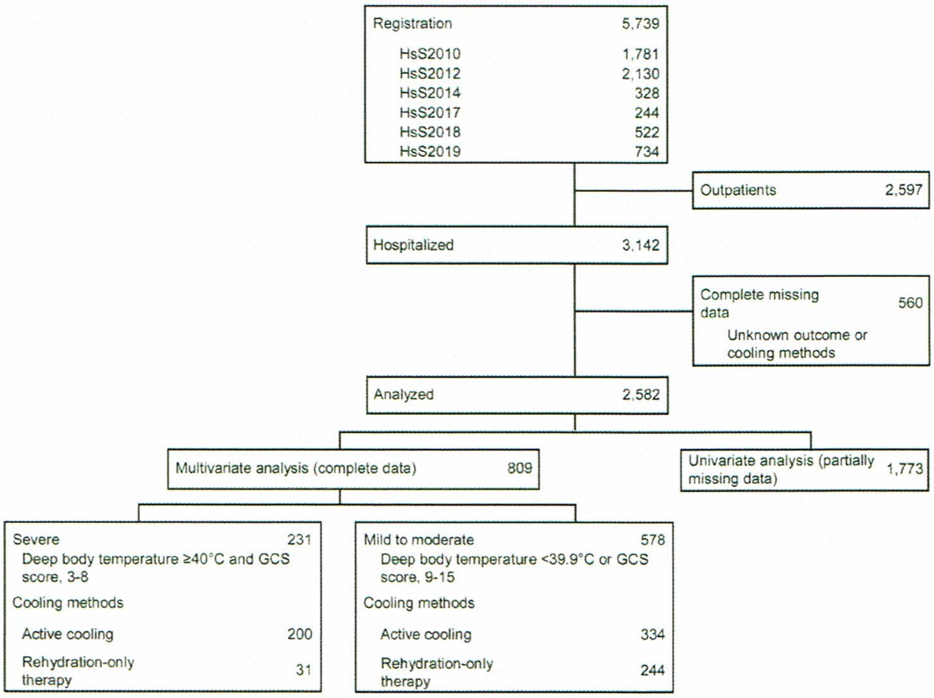

Fig 1. Patient selection process. Active cooling includes exclusively external, exclusively internal, and combined cooling. Rehydration-only therapy refers to fluid replacement without active cooling. HsS: Heat stroke Study; GCS: Glasgow Coma Scale.

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score, ≤8) or the mild-to-moderate group (i.e., all remaining patients), following Bouchama's severity classification based on the core body temperature and central nervous system abnormalities [29].

Endpoint

The endpoint was in-hospital mortality.

Cooling methods

We classified cooling methods as active cooling therapy or rehydration-only therapy. The former included internal, external, and combined cooling; all patients who were treated with active cooling were also treated with rehydration therapy. Various active cooling methods used in the participating facilities were categorized as follows: external cooling included the cooling of body surfaces through cold-water immersion, evaporative and convective cooling, and body-cooling units; internal cooling included cooling of the body cavity through gastric lavage and bladder irrigation with cold water and intravascular temperature management by saline circulation through catheter balloons or extracorporeal circulation; and combined cooling included combinations of internal and external cooling methods. Rehydration-only therapy comprised intravenous fluid replacement without active cooling, in which extracellular fluid (lactate Ringer's solution, acetate Ringer's solution, etc.) at room temperature was usually used. Although some facilities used a refrigerator-cooled solution, we did not consider such therapy as an active cooling method because the fluid was not kept cool during infusion. We did not collect information on fluid temperature.

This classification of cooling methods is based on Bouchama's theory of heat transmission in the human body [29]. Excess heat of the body core is transmitted to the body surface through the blood and by direct heat conduction. Furthermore, vasodilation increases blood flow to the skin. Heat is thereafter released into the atmosphere through the skin, usually by sweat evaporation. Cooling methods can apply to each of these processes. External cooling facilitates heat exchange through the body's surfaces and internal cooling through the body's core. Fluid replacement may enhance heat transfer from the core to the surface.

Variables

We classified age as <5 years, 15–44 years, 45–64 years, 65–74 years, and ≥75 years; core body temperature as <39.0°C (<312.15 K), 39.0°C–39.9°C (312.15–313.05 K), 40.0–40.9°C (313.15–314.05 K), 41.0–41.9°C (314.15–315.05 K), and ≥42.0°C (≥315.15 K); GCS score as 3–5, 6–8, 9–14, and 15; onset situation as exertional (e.g., sports and labor) and non-exertional (e.g., everyday life); and year as 2010–2012 and 2014–2018. We defined liver damage, based on an aspartate transaminase level of ≥30 U/L (0.5 μkat/L) or an alanine aminotransferase level of ≥42 U/L (men: 0.7 μkat/L)/≥) or ≥23 U/L (women: 0.38 μkat/L); renal dysfunction based on a creatinine level of ≥1.07 mg/dL (men: 94.61 μmol/L)/≥) or ≥0.80 mg/dL (women: 70.74 μmol/L); and DIC based on a score ≥4 (Japanese Association for Acute Medicine scoring) [30]. This DIC score reflects DIC severity ranging from 0 (mild) to 6 (severe), depending on the presence of systemic inflammatory response syndrome, thrombocytopenia, prothrombin time international normalized ratio prolongation, and D-dimer increase.

Data analysis

We stratified the patients with complete data into the "severe" group or the "mild-to-moderate" group and analyzed the group-wise association between cooling methods and in-hospital deaths. We conducted logistic regression analysis with in-hospital death as the dependent variable and the cooling method as the main independent variable. We also conducted a multivariate analysis to adjust for the following covariates that are likely to be associated with the prognoses of heat illness patients: sex, age, onset situation (i.e., exertional or non-exertional), core body temperature, liver damage, renal dysfunction, and DIC [31–34]. We also included the years when the HsS was conducted to consider unmeasured environmental, clinical, or meteorological changes. The variables were dichotomized before logistic regression analyses as follows: (1) cooling methods: active cooling, rehydration-only therapy; (2) sex: female, male; (3) age (years): ≤64, ≥65; (4) years: 2010–2014, 2017–2019; (5) onset situation: exertional, non-exertional; (6) core body temperature: <40.9°C and ≥41.0°C; (7) GCS score: 3–5 and 6–15; (8) liver damage: absent or present; (9) renal dysfunction: absent, present; and (10) DIC score ≥4 or ≤4. For each variable, we calculated the crude odds ratio in the univariate analysis and adjusted odds ratio (aOR) in the multivariate analysis, along with their respective 95% confidence intervals (CIs). The multivariate model included all of the abovementioned independent variables. We used SPSS Statistics version 25 (IBM, Armonk, NY) for the data analysis.

The sample size was determined in advance using the number of patients registered in the database. Therefore, we calculated the minimum detectable effect size for the given sample. The odds ratio needed to be 3.21 or higher to achieve statistical significance based on the given sample size of the severe cases (n = 231), the proportion of patients receiving rehydration-only therapy (13.4%), a 5% probability of type one error, a power of 0.8, and an assumption that the mortality rate among severe patients treated with active cooling methods was 20%. We used G*power ver.3.1.9.2 for this calculation [35].

We conducted univariate analyses among patients with missing data (S1 Fig). We excluded patients with unknown cooling methods and missing outcomes and classified the remaining patients into four groups: (1) patients with complete data of core body temperature ≥40.0˚C (≥313.15 K) and GCS 3–8 (i.e., severe); (2) patients with incomplete severity data but who were likely to be classified as severe, based on the core body temperature (i.e., ≥40.0˚C [≥313.15 It]) or GCS of 3–8 (i.e., likely to be severe); (3) patients with a core body temperature of <40.0˚C (<313.15 K) or GCS 9–15 (i.e., mild-to-moderate); and (4) patients with completely missing severity data (i.e., unknown severity; S1 Fig). We thereafter compared the group-wise mortality rates.

Results

Of the 809 patients analyzed for this study, 231 patients were categorized as "severe" and 578 patients as "mild-to-moderate." Most patients received active cooling therapy (Table 1). Among all participants, men and individuals aged ≥65 years accounted for 69% and 61%, respectively. Non-exertional mechanisms were seen in 66% patients. Some mild-to-moderate patients had severe symptoms: 18% had a high body temperature (≥40˚C), 15% had a GCS score ≤8, 64% had liver damage, and 77% had renal dysfunction. DIC and in-hospital death occurred in 28% and 15%, respectively, of the "severe" patients, and in 23% and 5%, respectively, of the "mild-to-moderate" patients. Among the severe cases, rehydration-only therapy was mostly provided to individuals aged ≥65 years. No apparent differences existed in the characteristics between therapies provided to patients in the "severe" and "likely to be severe" categories.

Among the severe cases, rehydration-only therapy was significantly associated with higher in-hospital mortality (aOR, 3.29; 95% CI: 1.21–8.90). Among the mild-to-moderate patients, cooling methods were not associated with lower mortality (aOR, 2.32; 95% CI: 0.92–5.84). Lower GCS scores and the presence of DIC were associated with an increased risk of in-hospital deaths among the "severe" and "likely to be severe" cases. The presence of liver damage was associated with a higher in-hospital mortality only in the severe cases (Table 2).

Among 1773 patients with partial missing data, 102 patients were categorized as "severe;" 161 patients, as "likely to be severe;" 1405 patients, as "mild-to-moderate;" and 105 patients, as "unknown severity" (S1 Table). In-hospital death rates were higher for "severe" and "likely to be severe" patients who received rehydration-only therapy than for those who received active cooling: 33% vs. 22%, respectively, and 29% vs. 23%, respectively. These rates were lower among "mild-to-moderate" patients (1% vs. 4%) and "unknown severity" patients (0% vs. 14%). S2 Table presents the results of the univariate analysis. S3 Table presents the characteristics of the excluded patients with missing data; the findings did not differ from those of the included patients.

Discussion

This study compared the prognosis of heat stroke and heat exhaustion patients treated with active cooling methods or with rehydration-only therapy using data from a nationwide heat stroke and heat exhaustion registry database. This study showed that, after adjusting for potential covariates, patients with severe cases of heat illnesses in which active cooling was administered were more likely to survive hospitalization than those who received rehydration-only therapy. Our findings suggest that active cooling is important to improve the outcomes of severe heat illness patients. Rehydration is an important component of heat illness management; however, it may not provide sufficient benefit to severe cases without concurrent active cooling.

Table 1. Distribution of factors potentially associated with patient prognosis after heat illness onset.

	Cooling method			
	Severe group		Mild-to-moderate group	
	Active cooling (n = 200) [a]	Rehydration-only therapy (n = 31) [b]	Active cooling (n = 334) [a]	Rehydration-only therapy (n = 244) [b]
	n (%)	n (%)	n (%)	n (%)
In-hospital deaths, n (%)	43 (21.5)	11 (35.5)	13 (3.9)	14 (5.7)
Cooling method, n (%)				
Exclusively external cooling	91 (45.5)	0 (0.0)	242 (72.5)	0 (0.0)
Exclusively internal cooling	13 (6.5)	0 (0.0)	17 (5.1)	0 (0.0)
Combined cooling	96 (48.0)	0 (0.0)	75 (22.5)	0 (0.0)
Rehydration-only therapy	0 (0.0)	31 (100.0)	0 (0.0)	244 (100.0)
Male patient, n (%)	142 (71.0)	16 (51.6)	229 (68.6)	172 (70.5)
Age (y), n (%)				
0–14	0 (0.0)	0 (0.0)	5 (1.5)	3 (1.2)
15–44	27 (13.5)	2 (6.5)	44 (13.2)	44 (18.0)
45–64	67 (33.5)	2 (6.5)	71 (21.3)	52 (21.3)
65–74	37 (18.5)	12 (38.7)	60 (18.0)	44 (18.0)
≥75	69 (34.5)	15 (48.4)	154 (46.1)	101 (41.4)
Study year, n (%) [c]				
2010	69 (34.5)	1 (3.2)	94 (28.1)	43 (17.6)
2012	20 (10.0)	3 (9.7)	25 (7.5)	24 (9.8)
2014	14 (7.0)	7 (22.6)	49 (14.7)	16 (6.6)
2017	8 (4.0)	0 (0.0)	22 (6.6)	34 (13.9)
2018	33 (16.5)	8 (25.8)	76 (22.8)	42 (17.2)
2019	56 (28.0)	12 (38.7)	68 (20.4)	85 (34.8)
Onset situation, n (%) [d]				
Non-exertional	133 (66.5)	25 (80.6)	227 (68.0)	148 (60.7)
Exertional	67 (33.5)	6 (19.4)	107 (32.0)	96 (39.3)
Core body temperature (°C), n (%)				
42.0+	55 (27.5)	5 (16.1)	5 (1.5)	0 (0.0)
41.0–41.9	85 (42.5)	13 (41.9)	20 (16.0)	4 (1.6)
40.0–40.9	60 (30.0)	13 (41.10)	58 (17.4)	19 (7.8)
39.0–39.9	0 (0.0)	0 (0.0)	119 (35.6)	45 (18.4)
<38.9	0 (0.0)	0 (0.0)	32 (39.5)	176 (72.1)
Glasgow Coma Scale score, n (%)				
3–5	151 (75.5)	21 (67.7)	37 (11.1)	14 (5.7)
6–8	49 (24.5)	10 (32.3)	26 (7.8)	12 (4.9)
9–14	0 (0.0)	0 (0.0)	217 (65.0)	133 (54.5)
15	0 (0.0)	0 (0.0)	54 (16.2)	85 (34.8)
Liver damage, number (%) [e]				
Present	169 (84.5)	25 (80.6)	221 (66.2)	148 (60.7)
Renal dysfunction, number (%) [f]				
Present	180 (90.0)	27 (87.1)	261 (78.1)	186 (76.2)
DIC, n (%) [g]				

(*Continued*)

Table 1. (Continued)

	Cooling method			
	Severe group		Mild-to-moderate group	
	Active cooling (n = 200) [a]	Rehydration-only therapy (n = 31) [b]	Active cooling (n = 334) [a]	Rehydration-only therapy (n = 244) [b]
	n (%)	n (%)	n (%)	n (%)
DIC score ≥4	57 (28.5)	8 (25.8)	49 (14.7)	37(15.2)

[a] Includes exclusively external, exclusively internal, and combined cooling. External cooling is the cooling of body surfaces through cold-water immersion, evaporative plus convective cooling, and body-cooling units. Internal cooling is the cooling of the body cavity through gastric lavage and bladder irrigation with ice water, intravascular ice cradle, and temperature management by extracorporeal membrane oxygenation. Combined cooling is the combination of internal and external cooling methods.

[b] Fluid replacement without active cooling.

[c] Indicates the year when the Heat stroke Study was conducted.

[d] Non-exertional onset condition is the onset of heat illness during participation in daily activities; exertional onset condition is the onset of heat illness during participation in sports and labor.

[e] Damage, as indicated by an aspartate transaminase level of ≥30 U/L (0.5 μkat/L) or an alanine aminotransferase level of ≥42 U/L (men: 0.7 μkat/L) or ≥23 U/L (women: 0.38 μkat/L).

[f] Dysfunction, as indicated by a creatinine level of ≥1.07 mg/dL (men: 94.61 μmol/L) or ≥0.80 mg/dL (women: 70.74 μmol/L).

[g] Disseminated intravascular coagulation (DIC), defined as a score ≥4, based on the Japanese Association for Acute Medicine scoring system.

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By contrast, active cooling was not associated with lower mortality among patients with mild-to-moderate cases. This finding does not imply that active cooling is useless in cases of heat exhaustion. Mortality rates among mild-to-moderate cases may be too low to detect differences. Other prognostic variables such as neurological complications could more appropriately be used to evaluate the treatment effects. However, they are not available in the database.

The large scale of this study allowed us to evaluate the benefits of active cooling in heat illness patients by using the patients' prognosis as the endpoint rather than by using a proxy measure. Severe heat stroke that results in death is a rare condition; therefore, single-center studies cannot include a sufficient number of severe cases to evaluate treatment effects on mortality. Most previous studies have consequently used proxy measures such as the speed of lowering the core body temperature [36] to evaluate treatment effects among mild-to-moderate cases (i.e., heat exhaustion) that had mostly no severe outcomes (i.e., mortality or complications) [12].

In addition, we determined the associations between active cooling and patients with heat illness and compared these with those of patients who received rehydration-only therapy. Active cooling is the standard treatment for severe heat stroke; therefore, a small proportion of patients receive rehydration-only therapy [29]. Our multicenter study included a sufficient number of these patients to allow comparisons.

We did not explore why some patients, particularly patients in the "severe" group, did not receive active cooling, although it is the standard therapy. A possibility is that emergency physicians who prescribed rehydration-only therapy may have overestimated its effects of enhancing blood flow for heat exchange [37]. An alternative reason is that they may have hesitated using active cooling because of peripheral vasoconstriction and shivering, which may delay surface heat exchange and temperature reduction [38]. However, we observed the insufficiency of rehydration-only therapy to improve patients' prognosis. We should suggest that guidelines strongly recommend the application of active cooling methods to heat illness patients.

This study has several limitations. First, compared to interventional studies, the observational nature of the study limits the inference of causality. Nonetheless, ethical concerns

Table 2. Odds ratios of factors potentially associated with patient prognosis after heat illness onset.

	Heat stroke (severe) (n = 231)		Heat exhaustion (mild-to-moderate) (n = 578)	
	cOR (95% CI)	aOR (95% CI)	cOR (95% CI)	aOR (95% CI)
Cooling methods (ref: active cooling) [a]				
Rehydration-only therapy [b]	2.01 (0.89–4.51)	3.29 (1.21–8.90)	1.50 (0.69–3.26)	2.32 (0.92–5.84)
Sex (ref: female)				
Male	0.90 (0.47–1.73)	1.34 (0.60–2.99)	0.53 (0.25–1.17)	0.80 (0.31–2.11)
Age (ref: ≤64)				
≥65 y	1.10 (0.59–2.03)	0.74 (0.32–1.69)	2.80 (1.04–7.49)	2.45 (0.76–7.92)
Study year (ref: 2017–2019) [c]				
2010–2014	0.58 (0.31–1.07)	0.53 (0.26–1.07)	0.98 (0.89–1.09)	1.76 (0.72–4.30)
Onset situation (ref: exertional) [d]				
Non-exertional	1.43 (0.72–2.83)	1.27 (0.54–2.96)	3.25 (1.11–9.53)	2.01 (0.56–7.14)
Core body temperature (ref: <40.9˚C)				
≥41.0˚C	1.84 (0.90–3.75)	1.48 (0.67–3.29)	0.00 (0.00-)	0.00 (0.00-)
Glasgow Coma Scale score (ref: 6–15)				
3–5	4.30 (1.62–11.40)	4.76 (1.64–13.78)	14.96 (6.55–34.15)	15.56 (5.90–41.04)
Liver damage (ref: absent) [e]				
Present	4.04 (1.19–13.73)	3.09 (0.85–11.24)	4.78 (1.42–16.06)	3.36 (0.92–12.31)
Renal dysfunction (ref: absent) [f]				
Present	3.69 (0.84–16.23)	3.28 (0.68–15.75)	2.42 (0.71–8.17)	1.03 (0.27–3.92)
DIC (ref: DIC score ≤4) [g]				
DIC score ≥4	3.29 (1.73–6.24)	4.17 (1.96–8.87)	5.16 (2.32–11.45)	3.39 (1.34–8.59)

All variables were dichotomized before single variable and multivariable logistic analyses.

cOR: crude odds ratio (univariate analysis), aOR: adjusted odds ratio (multivariable analysis).

[a] Includes exclusively external, exclusively internal, and combined cooling.

[b] Fluid replacement without active cooling.

[c] Year when the Heat stroke Study was conducted.

[d] Non-exertional onset situation is the onset of heat illness during participation in daily life activities. Exertional onset situation is the onset of heat illness during participation in sports and labor.

[e] Damage, as indicated by an aspartate transaminase level of ≥30 U/L (0.5 μkat/L) or alanine aminotransferase level of ≥42 U/L (men: 0.7 μkat/L) or ≥23 U/L (women: 0.38 μkat/L).

[f] Dysfunction, as indicated by a creatinine level of ≥1.07 mg/dL (men: 94.61 μmol/L) or ≥0.80 mg/dL (women: 70.74 μmol/L).

[g] Disseminated intravascular coagulation (DIC), defined as a score ≥4, based on the Japanese Association for Acute Medicine scoring system.

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prevent a study design in which patients are assigned rehydration-only therapy instead of the standard treatment (i.e., active cooling). Second, we were unable to collect standardized data on the influence of cooling speed, target temperature, and different types of external cooling methods because of interinstitutional differences and lack of specific guidelines regarding active cooling methods. Therefore, some patients may have received active cooling at a slower than recommended speed [38, 39]. This factor could have reduced the improvement of active cooling patients' outcomes, but we were able to demonstrate its effectiveness. Therefore, this limitation is unlikely to affect the results of this study.

Third, we did not collect data on the treatment of injured organs after body cooling. We assumed that timely body cooling could prevent organ injuries; moreover, no recommended treatments for organ injuries after active cooling among heat stroke patients exist [11]. Therefore, non-adjustment for treatments in the multivariate model was unlikely to distort our results.

Finally, we excluded many patients because of missing data. Among these, "severe" or "near-severe" patients had increased in-hospital mortality when receiving rehydration-only therapy, whereas "mild-to-moderate" patients had not increased mortality when receiving rehydration-only therapy. The severity, outcome, or applied cooling method were unknown in a few individuals, but these lacking data did not affect the results. If these patients had been included in the main analysis without the missing data, the efficacy of active cooling among severe cases would have remained unchanged.

Conclusions

Active cooling was associated with lower in-hospital mortality among severe cases of heat illness than was rehydration-only therapy; however, this finding did not occur for mild-to-moderate cases of heat illness. Our results support the recommendation of applying active cooling to reduce the core body temperature in addition to rehydration therapy for heatstroke patients.

Supporting information

S1 Fig. Selection process of patients with partially missing data. Active cooling includes exclusively external, exclusively internal, and combined cooling. Rehydration-only therapy refers to fluid replacement alone without active cooling. GCS: Glasgow Coma Scale.
(DOCX)

S1 Table. Outcomes and characteristics of patients (n = 1773) with partially missing data.
(DOCX)

S2 Table. Crude odds ratios of factors potentially associated with the prognoses of patients with partially missing data.
(DOCX)

S3 Table. Outcomes and characteristics of patients with completely missing data (n = 560).
(DOCX)

S1 Text. Participating hospitals and data collection periods.
(DOCX)

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Original Article

Influence of the coronavirus disease 2019 (COVID-19) pandemic on the incidence of heat stroke and heat exhaustion in Japan: a nationwide observational study based on the Heatstroke STUDY 2019 (without COVID-19) and 2020 (with COVID-19)

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Aim: To assess heat stroke and heat exhaustion occurrence and response during the coronavirus disease 2019 pandemic in Japan.

Methods: This retrospective, multicenter, registry-based study describes and compares the characteristics of patients between the months of July and September in 2019 and 2020. Factors affecting heat stroke and heat exhaustion were statistically analyzed. Cramér's V was calculated to determine the effect size for group comparisons. We also investigated the prevalence of mask wearing and details of different cooling methods.

Results: No significant differences were observed between 2019 and 2020. In both years, in-hospital mortality rates just exceeded 8%. Individuals >65 years old comprised 50% of cases and non-exertional onset (office work and everyday life) comprised 60%–70%, respectively. The recommendations from the Working Group on Heat Stroke Medicine given during the coronavirus disease pandemic in 2019 had a significant impact on the choice of cooling methods. The percentage of cases, for which intravascular temperature management was performed and cooling blankets were used increased, whereas the percentage of cases in which evaporative plus convective cooling was performed decreased. A total of 49 cases of heat stroke in mask wearing were reported.

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Conclusion: Epidemiological assessments of heat stroke and heat exhaustion did not reveal significant changes between 2019 and 2020. The findings suggest that awareness campaigns regarding heat stroke prevention among the elderly in daily life should be continued in the coronavirus disease 2019 pandemic. In the future, it is also necessary to validate the recommendations of the Working Group on Heatstroke Medicine.

Key words: Active cooling, COVID-19, heat exhaustion, heat stroke, mask wearing

INTRODUCTION

HEAT STROKE AND heat exhaustion are growing public health concerns worldwide because of the increasing frequency of heat waves. In Japan, 43,060 patients with heat stroke and heat exhaustion were transported by ambulance in August 2020 alone.[1] Moreover, coronavirus disease 2019 (COVID-19) has similar clinical symptoms, including fever and disturbance of consciousness, making it difficult to differentiate from heat stroke.[2] Compounded with the ongoing pandemic, as of September 1, 2021, the COVID-19 pandemic has resulted in more than 1,500,000 cases and 16,000 deaths.[3]

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been reported to survive for several hours in airborne aerosols and COVID-19 may be transmitted through microparticles and vectors.[4] In an attempt to curtail transmission, mask wearing has become a key preventative behavior during the COVID-19 pandemic. Although there are no known reports of an increase in the number of heat stroke patients after wearing masks, studies have shown that mask wearing increases oral and tympanic membrane temperature and increases the risk of heat illness during summer by increasing the temperature of inhaled air.[5,6]

SARS-CoV-2 is present not only in the upper respiratory tract, but also in the stool, urine, and blood, and viral particles have been detected in these for at least 2 weeks after contamination.[7] Therefore, it should be assumed that SARS-CoV-2 is present on body surfaces and in exhaled air. Moreover, evaporative plus convective cooling is one of the most common active cooling methods for heat stroke and may produce aerosols when water evaporates from the body surface.[8–11] As such, the risk of viruses on the body surface spreading infection via aerosols generated on the body surface cannot be ruled out in evaporative plus convective cooling methods against heat stroke with COVID-19. Therefore, to strengthen and improve infection control against COVID-19, it is necessary to adopt preventive measures and treatments for heat stroke and heat exhaustion.[2]

The Japanese Association for Acute Medicine (JAAM) Heatstroke and Hypothermia Surveillance Committee jointly established the Working Group on Heatstroke Medical Care given the COVID-19 epidemic with the Japanese Society for Emergency Medicine, Japanese Association for Infectious Diseases, and Japanese Respiratory Society. Recommendations for mask wearing include the avoidance of long-term exercise for ≥1 hour and to select an alternative cooling method to the evaporative plus convective cooling method, depending on the experience and conditions at each facility.[2] The JAAM Heatstroke and Hypothermia Surveillance Committee has been conducting a 3-year epidemiological study on heat stroke and heat exhaustion from 2019 to 2021 (Heatstroke STUDY [HsS] 2019–2021) independent of the COVID-19 pandemic. This study aimed to provide an interim report comparing data from 2019 and 2020 to clarify the effects of the COVID-19 pandemic on the incidence of heat stroke and heat exhaustion in Japan. By retrospectively comparing data before (2019) and during (2020) the pandemic, we aimed to understand the characteristics of the incidence of heat stroke in the context of the COVID-19 pandemic.

METHODS

Study design

THIS RETROSPECTIVE, OBSERVATIONAL, multicenter, registry-based study used data from the HsS 2019 and 2020, a nationwide periodical and prospectively collected registry of patients with heat stroke and heat exhaustion. Patient characteristics in HsS 2019 and 2020 were compared. The protocol for this research project was approved by the Teikyo University Ethical Review Board for Medical and Health Research (approval no. 17-021-5) and that of each participating hospital, and conforms to the provisions of the Declaration of Helsinki. Informed consent was provided in a manner specified by the ethics committee of each institution for this study, and data from patients who did not wish to participate were excluded.

The JAAM Heatstroke and Hypothermia Surveillance Committee conducted the HsS 2019 and 2020 between the months of July and September in 2019 and 2020, in which 109 and 142 hospitals participated, respectively. The registered cases were defined as hospitalized patients who were treated as having heat stroke and heat exhaustion in the emergency department, based on symptoms (high body temperature and signs of dehydration, such as dizziness, myalgia, headache, nausea, convulsions, disturbance of consciousness, and convulsions) and a history of exposure to hot environments.

Physicians collected patient data from medical records and registered the data in the HsS 2019 and 2020 study repository using a web-based data collection system. Detailed information on symptom onset (patients' activity and environment of heat illness onset), demographic data (age, sex, height, and weight), clinical data at hospital arrival (bladder or rectal temperature, Glasgow coma scale [GCS] score, and laboratory data on liver, hepatic, and coagulation functions), and information on cooling methods and in-hospital deaths were collected. In HsS 2020, data on mask wearing at the time of onset were also collected.

Variables

Deep body temperature was classified into five levels: ≥42.0°C, 41.0–41.9°C, 40.0–40.9°C, 39.0–39.9°C, and ≤38.9°C. The measurement sites were classified as follows: rectum, bladder, esophagus, tympanic membrane, intravascular, brain, and other than the above. Cooling methods were classified as active cooling therapy or rehydration-only therapy used in hospitals. Active cooling included internal, external, and combined cooling; all patients who were treated with active cooling were also treated with rehydration therapy. Active cooling methods used in the participating facilities were categorized as external cooling (cooling of body surfaces via evaporative plus convective cooling, the Arctic Sun temperature management system, cooling blanket, and cold-water immersion), internal cooling (cold-water gastric lavage, intravascular temperature management, cold-water bladder irrigation, renal replacement therapy, and extracorporeal membranous oxygenation), or combined cooling (combinations of internal and external cooling methods). The classification of the cooling methods did not overlap, although multiple answers were permitted. Rehydration-only therapy comprised intravenous fluid replacement without active cooling, in which extracellular fluid (such as lactate or acetate Ringer's solution) was typically used.

Onset environment was classified as exertional (manual labor and sports) and non-exertional (office work and everyday life). Liver damage was defined as aspartate transaminase levels ≥30 U/L or alanine aminotransferase levels ≥42 U/L in men and ≥23 U/L in women. Renal dysfunction was defined as creatinine ≥1.07 mg/dL in men and ≥0.80 mg/dL in women. The JAAM disseminated intravascular coagulation (DIC) score was calculated, and DIC was defined as a score of ≥4. The DIC score assesses DIC severity ranging from 0 (mild) to 6 (severe), depending on systemic inflammatory response syndrome, thrombocytopenia, prothrombin time international normalized ratio prolongation, and increases in D-dimer levels.[12]

To quantify the severity of the patients' condition, we used the JAAM Heatstroke Criteria (JAAM-HS criteria) and early risk assessment tool for detecting clinical outcomes in patients using a heat-related illness (J-ERATO) score. Based on JAAM-HS criteria, degree III (severe) was defined as any of the following: unconscious (Glasgow coma scale ≤14), liver damage, renal dysfunction, and DIC, whereas degree I–II (mild to moderate) was defined as the absence of these symptoms.[13] The J-ERATO score comprises six items (respiratory rate, GCS, systolic blood pressure, heart rate, body temperature, and age), each scoring 0 or 1, with a total score of 0-6 (mild, 0–1; moderate, 2–4; severe, 5–6).[14] The JAAM-HS criterion is a hospital assessment, and the J-ERATO score is a pre-hospital assessment. Although both include awareness level in the assessment items, they are independent severity assessment criteria.

Data analysis

To understand the impact of the COVID-19 pandemic, we described and compared the characteristics of patients in the HsS 2019 and HsS 2020. Statistical analysis was performed on factors of heat stroke and heat exhaustion, which include in-hospital deaths, cooling methods, sex, age, onset situation, mask wearing, deep temperature, GCS, liver damage, renal dysfunction, DIC, JAAM-HS criteria, and J-ERATO score. Missing values for each item were unknown cases and, therefore, excluded, and the ratio of each item between HsS 2019 and HsS 2020 was calculated and compared. In addition, we compared the in-hospital mortality rate and deep body temperature between mask wearers and non-mask wearers.

Cramér's V was calculated to determine the effect size for group comparisons; $P < 0.05$ and $V \geq 0.2$ were defined as indicating statistical and practical significance, respectively.[15] We only considered the ratio of mask wearing and details of cooling methods. SPSS Statistics version 28 (IBM Corporation) was used for the data analysis.

RESULTS

Study participants

A TOTAL OF 1,766 cases were included in the study. In HsS 2019, 734 patients were enrolled, of whom 247 received active cooling, 414 were treated with rehydration-

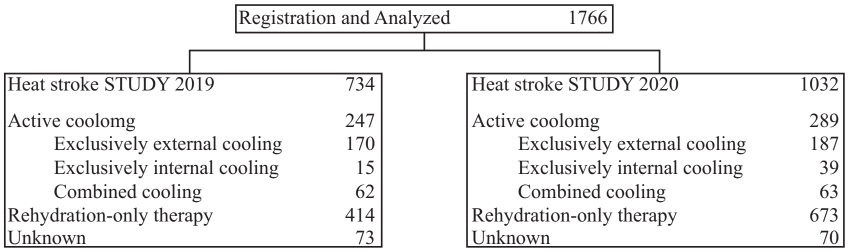

Fig. 1. Participants of the Heatstroke STUDY 2019 and 2020 categorized by cooling method.

only therapy, and 73 were treated with unknown cooling methods. In HsS 2020, 1,032 patients were enrolled, of whom 289 received active cooling, 673 were treated with rehydration-only therapy, and 70 were treated with unknown cooling methods (Fig. 1).

Factors of heat stroke and exhaustion

No significant differences were observed between HsS 2019 and HsS 2020 in terms of in-hospital deaths, cooling methods, sex, age, onset situation, mask wearing, deep temperature, measurement sites, GCS, liver damage, renal dysfunction, DIC, JAAM-HS criteria, and J-ERATO score. In both groups, in-hospital mortality rates just exceeded 8%. In HsS 2020, 49 cases (18.6%) were reported while mask wearing. In both HsS 2019 and HsS 2020, men comprised ~70% of cases, and individuals older than 65 years comprised 50% of cases. Non-exertional onset (office work and everyday life) and exertional onset (manual labor and sports) comprised 60%–70% and 30%–40% of cases, respectively. Regarding factors at the time of hospital visits, the deep body temperature was >40°C in <40% of patients. Deep body temperature was measured primarily in the rectum and bladder (Table 1). Of the cases, 25%–30% presented with severely impaired consciousness with GCS 3–8. Liver damage, renal dysfunction, and DIC were observed in 70%, 80%, and 20% of cases, respectively. Based on JAAM-HS criteria, degree III constituted the majority of cases (>97%). Mild (0–2), moderate (2–4), and severe (5–6) J-ERATO scores were observed in over 10%, ~50%, and just under 40% of cases, respectively (Table 1).

The proportion of individuals with a deep body temperature of <40.0°C was greater among mask wearers than among non-mask wearers, whereas the in-hospital mortality rate was lower for the former than for the latter (Table 2).

Cooling methods

Evaporative plus convective cooling, cold-water gastric lavage, intravascular temperature management, and cooling blankets were used in >10% of cases. In all cases, in which active cooling was performed, cooling methods that increased the ratio by >3.0% were intravascular temperature management and cooling blankets, whereas those that decreased the ratio by >3.0% were evaporative plus convective cooling and the Arctic Sun temperature management system. No changes >3.0% were observed for cold-water gastric lavage, cold-water bladder irrigation, cold-water immersion, renal replacement therapy, or extracorporeal membranous oxygenation. In this study, we only observed the changes in 2019 and 2020, and did not perform any statistical study (Table 3).

DISCUSSION

THIS NATIONWIDE OBSERVATIONAL study examined the effects of the COVID-19 pandemic on the incidence of heat stroke and heat exhaustion in Japan using data from HsS 2019 and 2020. Epidemiological assessments of heat stroke and heat exhaustion did not reveal any significant changes between 2019 and 2020. Indeed, the observation that ~ 60% of cases were non-exertional, ~ 70% were men, and the majority of cases occurred in individuals age ≥65 years has not changed from HsS 2017 to HsS 2018.[16] The current findings suggest that the incidence of heat stroke and heat exhaustion in Japan has not changed significantly as a result of the ongoing COVID-19 pandemic. Nevertheless, it is advisable to continue conventional activities to raise awareness to prevent heat stroke and heat exhaustion given the high incidence of these conditions in the elderly population.[17]

Based on the JAAM recommendations, we assumed that many facilities changed their cooling methods from evaporative plus convective cooling to intravascular temperature management or cooling blankets.[2] Aerosol generation in evaporative plus convective cooling warrants verification, although if its risk is indeed confirmed, JAAM recommendations may have been effective in preventing the occurrence of COVID-19 clusters in medical institutions.

Further, we identified an increase in the proportion of patients receiving rehydration-only therapy. This may be

Table 1. Patient characteristics in 2019 and 2020

	2019 (*n* = 734)		2020 (*n* = 1032)		V	*P*
	n	(%)	*n*	(%)		
In-hospital deaths, number (%)						
In-hospital deaths	54	(8.5)	76	(8.2)	0.004	0.879
Unknown	95		109			
Cooling methods, number (%)						
Exclusively external cooling	170	(25.7)	187	(19.4)	0.105	<0.001
Exclusively internal cooling	15	(2.3)	39	(4.1)		
Combined cooling	62	(9.4)	63	(6.5)		
Rehydration-only therapy	414	(62.6)	673	(70.0)		
Unknown	73		70			
Sex, no. (%)						
Male	498	(67.9)	717	(70.1)	0.023	0.336
Unknown	1		9			
Age, y, no. (%)						
0–14	13	(1.8)	22	(2.1)	0.041	0.556
15–44	107	(14.6)	132	(12.8)		
45–64	151	(20.7)	197	(19.1)		
65–74	132	(18.1)	180	(17.5)		
75+	328	(44.9)	498	(48.4)		
Unknown	3		3			
Onset situation, no. (%)						
Non-exertional	456	(63.7)	669	(66.2)	0.026	0.286
Exertional	260	(36.3)	342	(33.8)		
Unknown	18		21			
Mask wearing, no. (%)						
Mask wearing	–		49	(18.6)	–	–
No mask wearing	–		215	(81.4)		
Unknown	734		768			
Deep body temperature, °C, no. (%)						
≥42.0	26	(7.3)	15	(3.9)	0.103	0.099
41.0–41.9	53	(15.0)	43	(11.1)		
40.0–40.9	68	(19.2)	74	(19.2)		
39.0–39.9	74	(20.9)	95	(24.6)		
≤38.9	133	(37.6)	159	(41.2)		
Unknown	380		646			
Glasgow coma scale score, no. (%)						
3–5	126	(18.3)	148	(14.8)	0.061	0.103
6–8	62	(9.0)	93	(9.3)		
9–14	272	(39.4)	376	(37.6)		
15	230	(33.3)	383	(38.3)		
Unknown	44		32			
Measurement site, no. (%)						
Rectum	114	(32.7)	115	(30.4)	0.093	0.283
Bladder	219	(62.8)	240	(63.5)		
Esophagus	4	(1.1)	3	(0.8)		
Tympanic membrane	10	(2.9)	18	(4.8)		
Intravascular	2	(0.6)	0	(0.0)		
Brain	0	(0.0)	0	(0.0)		
Other than above	0	(0.0)	2	(0.5)		
Unknown	385		654			

Table 1. (Continued)

	2019 (n = 734)		2020 (n = 1032)		V	P
	n	(%)	n	(%)		
Liver damage, no. (%)						
Having liver damage	433	(61.9)	682	(67.9)	0.063	0.010
Unknown	34		28			
Renal dysfunction, no. (%)						
Having renal dysfunction	528	(75.5)	851	(84.4)	0.111	<0.001
Unknown	35		24			
DIC, no. (%)						
Having DIC	110	(24.0)	137	(19.2)	0.057	0.049
Unknown	276		319			
JAAM-HS criteria, no. (%)					0.004	0.854
I–II (mild to moderate)	18	(2.6)	28	(2.8)		
III (severe)	663	(97.4)	975	(97.2)		
Unknown	53		29			
J-ERATO score, no. (%)						
0	18	(3.2)	23	(3.0)	0.071	0.354
1	50	(8.9)	83	(10.7)		
2	69	(12.3)	105	(13.6)		
3	81	(14.5)	129	(16.7)		
4	128	(22.9)	160	(20.7)		
5	174	(31.1)	206	(26.6)		
6	39	(7.0)	67	(8.7)		
Unknown	175		289			

We calculated the ratio (%) and Cramér's V after excluding patients with unknown data in each category.
DIC, disseminated intravascular coagulation; J-ERATO score, the early risk assessment tool for detecting clinical outcomes in patients with heat-related illness score; SOFA score, the sequential organ failure assessment score.

Table 2. Characteristics and prognoses of patients who wore masks and those who did not

	Mask wearers (n = 49)		Non-mask wearers (n = 215)		V	P
	n	(%)	n	(%)		
In-hospital deaths, no (%)						
In-hospital deaths	1	(2.1)	23	(11.8)	0.130	0.043
Unknown	1		20			
Deep body temperature, °C, no. (%)						
≥42.0	0	(0.0)	2	(2.0)	0.187	0.382
41.0–41.9	2	(10.0)	8	(8.0)		
40.0–40.9	2	(10.0)	28	(28.0)		
39.0–39.9	5	(25.0)	26	(26.0)		
≤38.9	11	(55.0)	36	(36.0)		
Unknown	29		115			

We calculated the ratio (%) and Cramér's V after excluding all unknown patients in every category.

because of the recommendation to avoid the evaporative plus convective cooling method. Nevertheless, evidence supporting cooling rehydration-only therapy for active cooling is lacking, and many facilities may find it difficult to measure the actual liquid temperature of the infusion stored in a refrigerator.[2] Therefore, we caution against the easy use

Table 3. Details of active cooling in 2019 and 2020

Cooling methods†	2019 (n = 247)		2020 (n = 289)	
	n	(%)	n	(%)
Cold-water gastric lavage				
Internal cooling	34	(13.4)	38	(13.1)
Intravascular temperature management				
Internal cooling	27	(10.7)	44	(15.2)
Cold-water bladder irrigation				
Internal cooling	13	(5.1)	10	(3.5)
Renal replacement therapy				
Internal cooling	3	(1.2)	1	(0.3)
Extracorporeal membranous oxygenation				
Internal cooling	2	(0.8)	0	(0.0)
Evaporative plus convective cooling				
External cooling	197	(77.9)	178	(61.6)
The Arctic Sun temperature management system				
External cooling	17	(6.7)	8	(2.8)
Cooling blanket				
External cooling	16	(6.3)	39	(13.5)
Cold-water immersion				
External cooling	13	(5.1)	8	(2.8)
Unknown	12	(4.7)	23	(8.0)

†External cooling included the cooling of body surfaces via evaporative plus convective cooling, the Arctic Sun temperature management system, cooling blanket, and cold-water immersion; internal cooling included cold-water gastric lavage, intravascular temperature management, cold-water bladder irrigation, renal replacement therapy, and extracorporeal membranous oxygenation; and combined cooling included combinations of internal and external cooling methods.

of rehydration-only therapy, regardless of the liquid temperature of the infusion.

The onset of heat stroke and heat exhaustion during mask wearing had not been reported before 2019, but was confirmed in HsS 2020.[2] In this survey, although the mask wearing group tended to have more minor cases than did the non-mask wearing group, there were many unknown cases and only a few cases were actually reported. Accordingly, it is necessary to examine the details of the onset pattern to control COVID-19 and to prevent heat stroke and heat exhaustion.

This study has three main limitations. First, we did not perform a survey of the entire population. Therefore, the study may not directly reflect the actual situation, but may afford an inference of the general situation in the country or in a particular region. Second, this study did not examine the cooling methods according to disease severity. A comprehensive assessment of the type of treatment may be considered acceptable, although the severity and background of the patients must be matched to investigate the effects of cooling methods. Finally, hospitalized patients with heat stroke and heat exhaustion were included in this study, although the criteria for admission often depended on each institution and patient background; as such, the admission criteria may not have been uniform. Nevertheless, this is acceptable in this study because the purpose of this report was to provide a summary of a larger epidemiological study, although future studies using data from this registry should ensure that admission criteria are standardized.

CONCLUSION

THIS REPORT EXAMINED the impact of the COVID-19 pandemic on the incidence of heat stroke and heat exhaustion in Japan by comparing data from HsS 2019 and HsS 2020. Epidemiological assessments of heat stroke and heat exhaustion did not reveal significant changes between 2019 and 2020. Many facilities altered their cooling methods based on recommendations by the Working Group on Heatstroke Medical Care, which recommended the selection of alternative cooling methods to the evaporative plus convective cooling given the COVID-19 pandemic. This study shows that awareness of heat stroke prevention among the elderly in daily life should be continued in the COVID-19 pandemic as in the past. It is also necessary to validate the recommendations of the Working Group on Heatstroke Medical Care.

DISCLOSURE

APPROVAL OF THE Research Protocol: The protocol for this research project was approved by the Teikyo University Ethical Review Board for Medical and Health Research (approval no. 17-021-5) and that of each participating hospital.

Informed Consent: Informed consent was provided in a manner specified by the ethics committee of each institution for this study, and data from patients who did not wish to participate were excluded.

Registry and the Registration Number of the Study: N/A.

Animal Studies: N/A.

Conflict of Interest: None declared.

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Heatstroke STUDY 2019 (109 Facilities)

1. Aichi Medical University Hospital
2. Aidu Chuo Hospital
3. Aizawa Hospital
4. Asahikawa Medical University Hospital
5. Chiba University Hospital
6. Daiyukai General Hospital
7. Dokkyo Medical University Saitama Medical Center
8. Eastern Chiba Medical Center
9. Ehime Prefectural Central Hospital
10. Fujieda Municipal General Hospital
11. Fujisawa City Hospital
12. Fukui Prefectural Hospital
13. Funabashi Municipal Medical Center
14. Gifu Prefectural General Medical Center
15. Gifu University Hospital
16. Hamamatsu Medical Center
17. Handa City Hospital
18. Hiroshima City Hiroshima Citizens Hospital
19. Hyogo Prefectural Awaji Medical Center
20. Hyogo Prefectural Kakogawa Medical Center
21. Hyogo Prefectural Nishinomiya Hospital
22. Ichinomiya Municipal Hospital
23. Iizuka Hospital
24. Ina Central Hospital
25. Ishikawa Prefectural Central Hospital
26. Iwata City Hospital
27. Japanese Red Cross Ise Hospital
28. Japanese Red Cross Ishinomaki Hospital
29. Japanese Red Cross Kyoto Daini Hospital
30. Japanese Red Cross Maebashi Hospital
31. Japanese Red Cross Medical Center
32. Japanese Red Cross Narita Hospital
33. Japanese Red Cross Shizuoka Hospital
34. Japanese Red Cross Tokushima Hospital
35. Jichi Medical University Saitama Medical Center
36. Juntendo University Nerima hospital
37. Juntendo University Urayasu Hospital
38. Kagawa Prefectural Central Hospital
39. Kasugai Municipal Hospital
40. Kawasaki Municipal Hospital
41. Kitakyushu General Hospital
42. Kochi Health Sciences Center
43. Kurume University Hospital
44. Kushiro City General Hospital
45. Kyorin University Hospital
46. Kyoto University Hospital
47. Kyushu University Hospital
48. Mie University Hospital
49. Mito Saiseikai General Hospital
50. Nagoya Ekisaikai Hospital
51. Nagoya University Hospital
52. National Center for Global Health and Medicine
53. National Hospital Organization Hokkaido Medical Center
54. National Hospital Organization Kumamoto Medical Center
55. National Hospital Organization Osaka National Hospital
56. National Hospital Organization Takasaki General Medical Center
57. National Hospital Organization Yokohama Medical Center
58. Nihon University Hospital
59. Nihon University Itabashi Hospital
60. Nihonkai General Hospital
61. Niigata Prefectural Shibata Hospital
62. Nippon Medical School Tama Nagayama Hospital
63. Odawara Municipal Hospital
64. Oita University Hospital
65. Okazaki City Hospital
66. Okinawa Prefectural Chubu Hospital
67. Ome Municipal General Hospital
68. Omihachiman Community Medical Center
69. Osaka City General Hospital
70. Osaka Mishima Emergency Critical Care Center
71. Osaka Police Hospital
72. Osaka Prefectural Nakakawachi Emergency and Critical Care Center
73. Ota Medical Hospital
74. Saiseikai Utsunomiya Hospital
75. Saiseikai Yokohamashi Tobu Hospital
76. Saitama Medical University International Medical Center
77. Saku Central Hospital
78. Sapporo City General Hospital
79. Sapporo Medical University Hospital
80. Shinshu University Hospital
81. Shonan Kamakura General Hospital
82. Showa University Fujigaoka Hospital
83. St. Luke's International Hospital
84. St. Mary's Hospital
85. Sugita Genpaku Memorial Obama Municipal Hospital
86. Sunagawa City Medical Center

87. Teikyo University Hospital
88. Teine Keijinkai Hospital
89. The University of Tokyo Hospital
90. Toho University Omori Medical Center
91. Tohoku University Hospital
92. Tokai University Hachioji Hospital
93. Tokai University Hospital
94. Tokushima Prefectural Miyoshi Hospital
95. Tokyo Metropolitan Tama Medical Center
96. Tokyo Women's Medical University Hospital
97. Tokyo Women's Medical University Medical Center East
98. Tokyo Women's Medical University Yachiyo Medical Center
99. Tosei General Hospital
100. Toyama Prefectural Central Hospital
101. Toyama University Hospital
102. University of Yamanashi Hospital
103. Yamagata Prefectural Central Hospital
104. Yamagata University Hospital
105. Yamaguchi University Hospital
106. Yamanashi Prefectural Central Hospital
107. Yokkaichi Municipal Hospital
108. Yokohama Minami Kyosai Hospital
109. Yokohama Rosai Hospital

Heatstroke STUDY 2020 (142 Facilities)

1. Advanced Critical Care and Emergency Center, Yokohama City University Medical Center
2. Advanced Emergency and Critical Care Center, Kurume University Hospital
3. Aidu Center Hospital
4. Akita University Graduate School of Medicine, Department of Emergency and Critical Care Medicine
5. Asahikawa Medical University
6. Center Hospital of the National Center for Global Health and Medicine
7. Daiyukai General Hospital
8. Department of Emergency and Critical Care Medicine Hyogo Emergency Medical Center
9. Department of Emergency and Critical Care Medicine Faculty of Medicine, Saga University
10. Department of Emergency and Critical Care Medicine, Nara Medical University
11. Department of Emergency and Critical Care Medicine, Tohoku University Hospital
12. Department of Emergency, Disaster and Critical Care Medicine, Showa University School of Medicine
13. Dept of Emergency and Critical Care Center, Fukuoka University Hospital
14. Dokkyo Medical University Saitama Medical Center
15. Eastern Chiba Medical Center
16. Ehime Prefectural Central Hospital
17. Emergency Medical Center, Kagawa University Hospital
18. Fujieda Municipal General hospital
19. Fujisawa City Hospital
20. Fukaya Redcross Hospital
21. Fukui Prefectural Hospital
22. Funabashi Municipal Medical Center
23. Gifu Prefectural Central Medical Center
24. Hachinohe City Hospital
25. Hamamatsu Medical Center
26. Handa City Hospital
27. Hyogo Prefectural Kakogawa Medical Center
28. Hyogo Pref Awaji Medical Center
29. Hyogo Prefectural Nishinomiya Hospital
30. Ichinomiya Medical Hospital
31. Iizuka Hospital
32. Ina Central Hospital
33. Ishikawa Prefectural Central Hospital
34. Iwata City Hospital
35. Japanese Red Cross Akita Hospital
36. Japanese Red Cross Ashikaga Hospital
37. Japanese Red Cross Ise Hospital
38. Japanese Red Cross Ishinomaki Hospital
39. Japanese Red Cross Kumamoto Hospital
40. Japanese Red Cross Maebashi Hospital
41. Japanese Red Cross Medical Center
42. Japanese Red Cross Shizuoka Hospital
43. Japanese Red Cross Society Kyoto Daini Hospital
44. Japanese Red Cross Society Wakayama Medical Center
45. Juntendo University Nerima Hospital
46. Juntendo University Urayasu Hospital
47. Kagawa Prefectural Central Hospital
48. Kagoshima Prefectural Ohshima Hospital
49. Kansai Medical University Medical Center
50. Kansai Medical University Hospital
51. Kasugai Municipal hospital
52. Kawaguchi Municipal Medical Center
53. Kawasaki Medical School General Medical Center
54. Kawasaki Municipal Kawasaki Hospital
55. Kimitsu Chuo Hospital Department of Emergency and Critical Care Medicine
56. Kochi Medical School Hospital
57. Kochi Health Science Center
58. Kochi Red Cross Hospital
59. Kouseiren Takaoka Hospital
60. Kumamoto University Hospital Emergency and General Medicine
61. Kushiro City General Hospital

62. Kyorin University School of Medicine
63. Kyoto City Hospital
64. Kyoto University Hospital
65. Mie Prefectural General Medical Center
66. Mie University School of Medicine
67. Mito Saiseikai General Hospital
68. Nagahama Red Cross Hospital
69. Nagano Red Cross Hospital
70. Nagoya University Hospital
71. Nanbu Medical Center Nanbu Child Medical Center
72. Nara Prefecture General Medical Center
73. National Hospital Organization Disaster Medical Center
74. National Hospital Organization Kumamoto Medical Center
75. National Hospital Organization Kyoto Medical Center
76. National Hospital Organization Mito Medical Center
77. National Hospital Organization Takasaki General Medical Center
78. National Hospital Organization Yokohama Medical Center
79. Nayoro City General Hospital
80. Nigata Prefectural Shibata Hospital
81. Nihon University Itabashi Hospital
82. Nihonkai General Hospital
83. Niigata University Medical & Dental Hospital
84. Nippon Medical School Hospital
85. Nippon Medical School Tamanagayama Hospital
86. Noto General Hospital
87. Odawara Municipal hospital
88. Oita University Hospital Advanced Trauma, Emergency and Critical Care Center
89. Okazaki City Hospital
90. Okinawa Chubu Hospital
91. Okitama Public Hospital
92. Ome Municipal General Hospital
93. Osaka City General Hospital Emergency and Critical Care Medical Center
94. Osaka Mishima Emergency Medical Center
95. Osaka Prefectural Nakakawachi Emergency and Critical Care Medicine
96. Osaka Red Cross Hospital Department of Emergency Medicine
97. Osaka University Hospital
98. Osaki Citizen Hospital Emergency Center
99. Our Lady of the Snow Social Medical Corporation St. May's Hospital
100. Rinku General Medical Center
101. Saiseikai Kumamoto Hospital
102. Saiseikai Siga Hospital
103. Saiseikai Yokohamashi Tobu Hospital
104. Saitama Medical University International Medical Center
105. Saku Central Hospital Advanced Care Center
106. Sapporo Medical University Hospital
107. Sapporo City General Hospital
108. Seirei Mikatahara General Hospital
109. Shakaiiryouhoujinnzaidann Jisennkai Aizawabyouinn
110. Shimane University
111. Shimane Prefectural Central Hospital
112. Shinshu University Hospital
113. Shonan Kamakura General Hospital
114. South Miyagi Medical Center.
115. Sugita Genpaku Memorial Municipal Hospital
116. Sunagawa City Medical Center
117. Teikyo University Hospital
118. The University of Tokyo Hospital
119. Tokai University Hospital
120. Tokushima Prefectural Miyoshi Hospital
121. Tokushima Red Cross Hospital
122. Tokyo bay Urayasu Ichikawa Medical Center
123. Tokyo Medical University
124. Tokyo Medical and Dental University Medical Hospital
125. Tokyo Medical University Hachioji Medical Center
126. Tokyo Medical University Hachioji Medical Center
127. Tokyo Metropolitan Tama Medical Center
128. Tokyo Women's Medical University Medical Center East
129. Tosei Central Hospital
130. Toyama Prefectural Central Hospital
131. Toyama University Hospital
132. Toyohashi Medical Hospital
133. Tsukuba Medical Center Hospital
134. University Hospital, Kyoto Prefectural University of Medicine
135. University of the Ryukyus Hospital
136. Urasoe Central Hospital
137. Yamagata University Faculty of Medicine
138. Yamaguchi University Hospital
139. Yamanashi Prefectural Central Hospital
140. Yodogawa Christian Hospital
141. Yokohama Minami Kyousai Hospital
142. Yokosuka General Hospital Uwamachi

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Original Article

Wearing a face mask during controlled-intensity exercise is not a risk factor for exertional heatstroke: A pilot study

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Aim: This study aimed to measure the influence of wearing face masks on individuals' physical status in a hot and humid environment.

Methods: Each participant experienced different physical situations: (i) not wearing a mask (control), (ii) wearing a surgical mask, (iii) wearing a sport mask. An ingestible capsule thermometer was used to measure internal core body temperature during different exercises (standing, walking, and running, each for 20 min) in an artificial weather room with the internal wet-bulb globe temperature set at 28°C. The change in the participants' physical status and urinary liver fatty acid-binding protein (L-FABP) were measured.

Results: Six healthy male volunteers were enrolled in the study. In each participant, significant changes were observed in the heart rate and internal core temperatures after increased exercise intensity; however, no significant differences were observed between these parameters and urinary L-FABP among the three intervention groups.

Conclusion: Mask wearing is not a risk factor for heatstroke during increased exercise intensity.

Key words: COVID-19, dehydration, heatstroke, mask, prevention

INTRODUCTION

SINCE THE DISCOVERY of the coronavirus disease (COVID-19), significant changes have been made to people's lifestyles, including avoidance of closed and crowed places, social distancing measures, and wearing of masks to prevent the spread of infection. Considering the significant amount of time an individual wears a mask, it is important to consider the balance between heat exhaustion prevention and daily life activity, and to ensure physical cooling to prevent heatstroke. Moreover, patients with COVID-19 commonly present with fever and hyperthermia, causing difficulties in distinguishing between heatstroke and these symptoms.[1,2] Thus, there is an urgent need to discuss the prevention of heatstroke during this pandemic.

However, the influence of exercise in a hot and humid environment while wearing a mask on the incidence of heatstroke remains unclear.

Therefore, we aimed to measure the influence of wearing masks on the physical status of humans in artificial hot and humid environments.

MATERIALS AND METHODS

Experimental design, subjects, and intervention

THIS WAS A prospective experimental study that included human subjects.

Healthy young volunteers without physical or health problems were included in this study. The participants with high (≥37.5 °C) body temperature were excluded. Each participant was exposed to different physical situations, as follows: (i) not wearing a mask (control), (ii) wearing surgical

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Funding information

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mask (3M surgical mask; bacterial filtration efficiency [BFE], 99%; particle filtration efficiency [PFE], 95%), (iii) wearing a mask for sport use (UNIQLO Airism; BFE, 99%).

Six hours prior to the start of the experiment, the subjects were instructed to stop eating, to ensure precise measurement of the internal core body temperature using an ingestible capsule thermometer (e-Celsius; BodyCap). An emergency physician undertook a health examination on each subject to confirm the stability of their physical status, pre- and postexperiment.

The subjects swallowed an ingestible thermometer and their physical baseline status was measured (body weight, heart rate, respiratory rate, blood pressure, surface body temperature, total body water content, and saturation of percutaneous oxygen [SpO_2]). Subsequently, subjects were instructed to perform exercises (standing for 20 min, then walking for 20 min, and running for 20 min on a treadmill [Biomill VO-2000; Sandme]) in an artificial weather room in which the temperature was set at 28°C. The temperature was measured using the internal wet-bulb globe temperature (WBGT),[3] calculated with the equation: WBGT = 0.7 × wet-bulb temperature + 0.3 × globe temperature.

The exercise intensity was decided using the Karvonen formula (target heart rate = [(220 − age) − (resting heart rate) × (% of exercise intensity)] + resting heart rate).[4]

A schematic drawing of the experiment is shown in Figure 1. For each individual, the experiment phases involved three steps: rest (% of exercise intensity = 0), walking (low intensity: % of exercise intensity = 20%), and running phase (moderate intensity: % of exercise intensity = 70%).[5] At each step, after deciding the target heart rate using the Karvonen formula, the speed and tilt angle of the treadmill was increased every 2 min by the Bruce method.[6] After reaching the targeted heart rate, the speed and tilt angle of the treadmill were maintained for 20 min.

To ensure the participants' safety, exercise was discontinued when: (i) core body temperature reached 40°C, (ii) SpO_2 decreased by less than 90%, (iii) the Borg scale,[7] a scale of rate of perceived exertion, reached 17.

The definition of the incidence of heatstroke followed the Japanese Association for Acute Medicine heatstroke (JAAM-HS) criteria.[8] That is, the incidence of heatstroke was diagnosed as any initial symptoms such as vertigo, headache, vomiting, disturbance of consciousness, convulsion, ataxia, and delirium, under hot and humid situations.

One subject was tested every week with different situations with or without a mask; therefore, one subject was tested three times in 3 weeks.

Before the experiment, the study aims and procedures were fully explained to each participant; after receiving a description of the experiment, they signed an agreement to participate in the study. Thus, a statement of consent was obtained from all participants. This study was approved by the Institutional Review Board of Nippon Medical School (A-2020-029).

Body water content

Body water content was measured twice (before and after exercise) by multifrequency bioimpedance using a four-paired electrode bioimpedance device[9] (InBody 720). Additionally, several physical parameters, including total body water content, muscle mass, and body fat percentage, were measured.

Saturation of percutaneous oxygen and Pleth variability index

To measure the respiratory status, the time of initial and end SpO_2 were measured in each experimental trial.

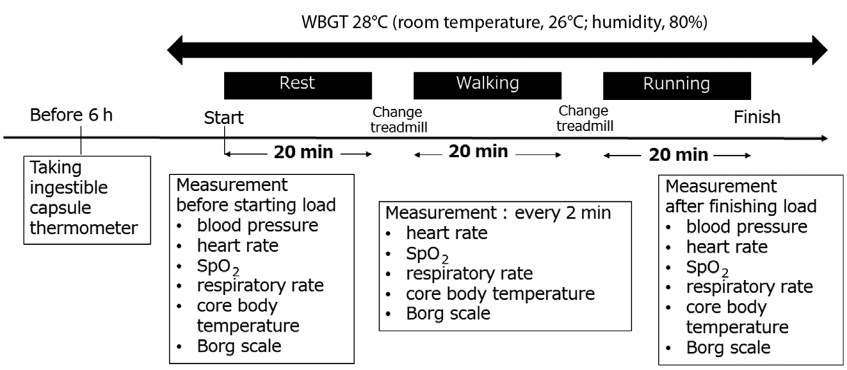

Fig. 1. Schema of experiment to determine whether wearing a face mask is a risk factor for heatstroke during increased exercise intensity. Each participant experienced different physical situations: (i) not wearing a mask (control), (ii) wearing a surgical mask, or (iii) wearing a mask for sport use. SpO_2, percutaneous oxygen saturation; WBGT, wet-bulb globe temperature.

Additionally, the Pleth variability index (PVI) was measured for intravenous fluid volume estimation.[10] Both SpO_2 and PVI were measured using a Radical-7 monitor (Masimo).

Liver fatty acid-binding protein measurement

To estimate the level of dehydration, the urinary concentration of liver fatty acid-binding protein (L-FABP) was measured.[11] In each subject, urinary samples (5 ml) were collected before and after exercise loading, and were stored at −80°C. Before batch analysis, urine samples were defrosted at air temperature. Urinary L-FABP concentrations were analyzed using an enzyme-linked immunosorbent assay with the Human L-FABP Kit (Sekisui Medical), according to the manufacturer's instructions.

Statistical analysis

A previous report stated that at least six participants are needed to estimate the relationship between mask wearing and physiological estimation.[12] The numerical data are presented as median and interquartile range. Categorical variables were compared using Fisher's exact test. The influence of time, face mask type, and their interactions on these human physiological and psychological responses were analyzed using repeated two-way measures ANOVA and the Wilcoxon signed rank test. Stat-Flex (Artech) was used to analyze the data. Statistical significance was set at $p < 0.05$.

RESULTS

Subject characteristics

SIX YOUNG JAPANESE men were included in this study. Their median age was 19.5 years (interquartile range, 19.0–21.0 years) and median body mass index was 23.2 g/m^2 (22.6 g/m^2–24.1 g/m^2). All patients had normal and stable physical status. Additionally, all vital signs were within normal range: baseline systolic blood pressure, 127.5 mmHg; baseline heart rate, 76.0 b.p.m.; baseline respiratory rate, 18.0 breaths/min; and baseline SpO_2, 98.0% in room air (Table 1). None of the participants had any comorbidities. In addition, the physical data of all participants were similar. The detailed characteristics are shown in Table 1.

Change over time of core temperature and other vital signs

Core temperature and heart rate was significantly increased when exercise intensity was increased (control, 37.4 °C–38.8 °C; surgical mask, 37.2 °C–38.7 °C; and fabric sport mask, 37.3 °C–38.7 °C; Figure 2). However, no significant difference was observed among the three groups (p = 0.74, Figure 3).

Saturation of percutaneous oxygen, respiratory rate, and PVI

Saturation of percutaneous oxygen significantly decreased in all six subjects (control, 98.0%–91.0%; surgical mask,

Table 1. Characteristics of human subjects (n = 6, male) in an experiment to determine whether wearing a face mask is a risk factor for heatstroke during increased exercise intensity

Subject no.	1	2	3	4	5	6	Median (IQR)
Age (years)	21	19	19	21	19	20	19.5 (19.0–21.0)
Height (cm)	177	169	175	162	176	160	172.0 (162.0–176.0)
Body weight (kg)	73.8	62.1	69.1	59.5	76.0	61.6	65.6 (61.6–73.8)
Body mass index (kg/m^2)	23.6	21.7	22.6	22.7	24.5	24.1	23.2 (22.6–24.1)
Total body water contents (L)	44.3	38.4	44.4	36.2	43.6	32.8	41.0 (36.2–44.3)
Muscle mass (kg)	57.0	49.5	57.2	46.6	56.2	42.3	52.5 (46.0-57.0)
Body fat percentage (%)	17.9	15.6	12.2	17.0	21.3	27.5	17.5 (15.6–21.3)
Initial systolic blood pressure (mmHg)	111	125	111	141	144	130	127.5 (111.0–141.0)
Initial diastolic blood pressure (mmHg)	76	73	62	86	96	76	76.0 (73.0–86.0)
Initial heart rate (b.p.m.)	59	55	55	73	72	70	64.5 (55.0-72.0)
Initial respiratory rate (breaths/min)	17	18	18	18	22	24	18.0 (18.0–22.0)
Initial SpO_2 (%)	98	98	99	99	97	96	98.0 (97.0–99.0)

Abbreviation: IQR, interquartile range.

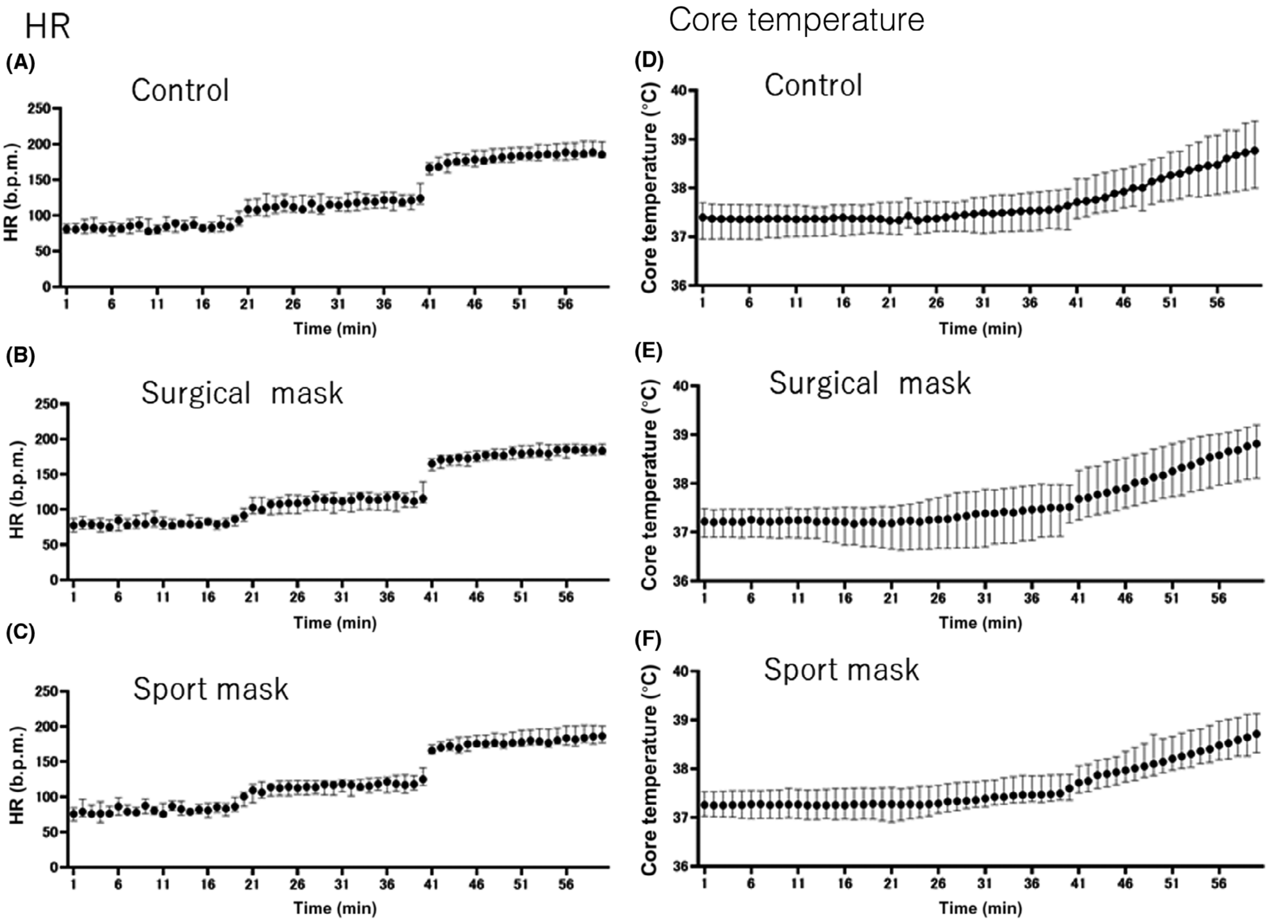

Fig. 2. Change of heart rate (A–C) and core temperature (D–F) in healthy young men during increased-intensity exercise while not wearing a mask (control), wearing a surgical mask, or wearing a mask for sport use. Heart rate (HR) and core temperature significantly increased; however, no significant difference was observed between the three groups.

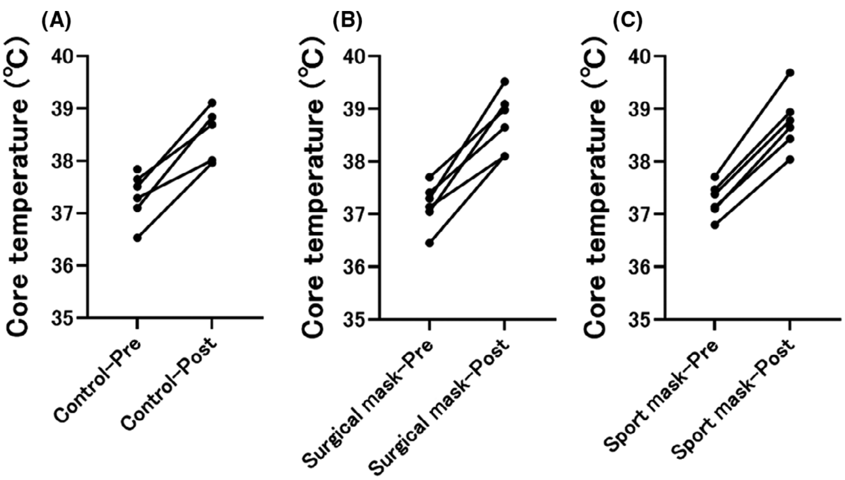

Fig. 3. Change of core temperature before and after exercise among healthy young men who were not wearing a mask (A), wearing a surgical mask (B), or wearing a sport mask (C). Core temperature significantly increased after exercise; however, no significant difference was observed between groups.

97.0%–94.0%; and fabric sport mask, 98.0%–93.0%; Figure 4A). However, no significant difference was observed regarding SpO_2 decrease in the three groups (p = 0.31). Conversely, respiratory rate was increased. However, no significant difference was observed in the three groups (Figure 4B).

The PVI, a measure of intravenous fluid volume (a high value of PVI indicates dehydration), significantly increased in all six subjects (control, 26.6 to 32.0; surgical mask, 17.5–21.0; and fabric sport mask, 21.6–29.5; Figure 5); however, no significant difference was observed among the groups (p = 0.43, Figure 5).

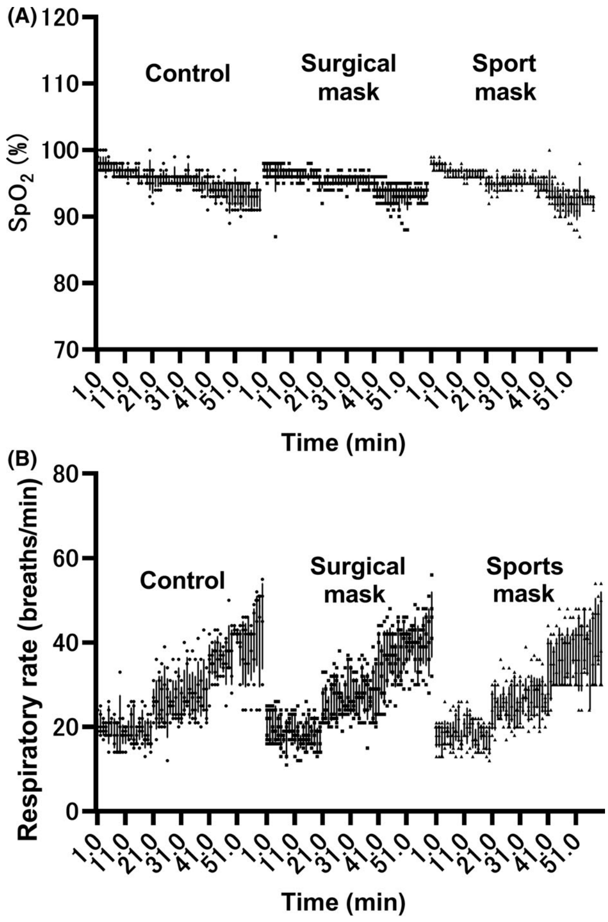

Fig. 4. Change in the saturation of percutaneous oxygen (SpO_2) (A) and respiratory rate (B) in healthy young men during increased-intensity exercise while not wearing a mask (control), wearing a surgical mask, or wearing a mask for sport use. The SpO_2 decreased and respiratory rate increased significantly in all subjects; however, no significant difference was observed between groups.

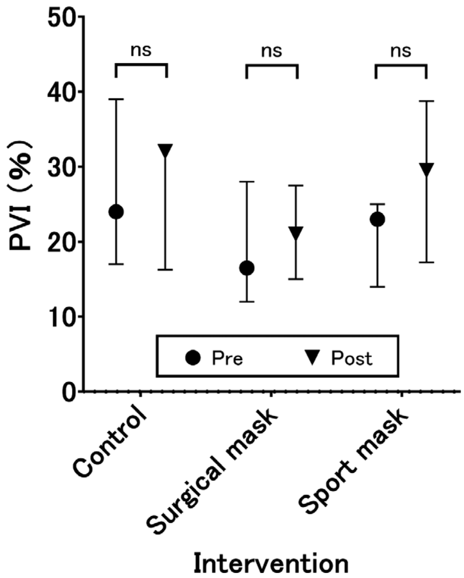

Fig. 5. Values of the Pleth variability index (PVI, %) before and after exercise among healthy young men who were not wearing a mask, wearing a surgical mask, or wearing a sport mask. No significant difference was observed in the PVI values after exercise, or between groups. ns, not significant.

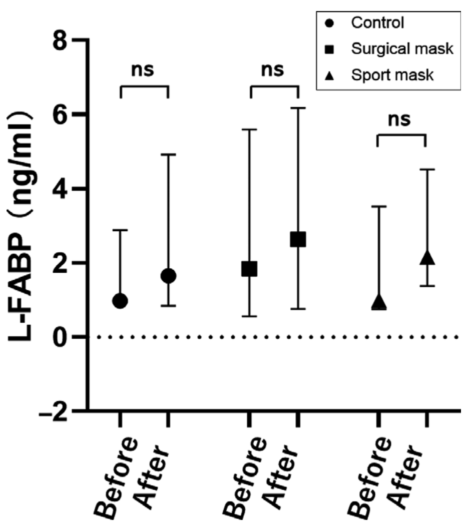

Fig. 6. Change in the concentration of urinary liver fatty acid-binding protein (L-FABP) before and after exercise among healthy young men who were not wearing a mask, wearing a surgical mask, or wearing a sport mask. No significant increase was observed and no significant difference was observed between groups regarding L-FABP levels. ns, not significant.

Liver fatty acid-binding protein

In each subject, no significant increase was observed in the L-FABP pre- and postexercise loading. Furthermore, no

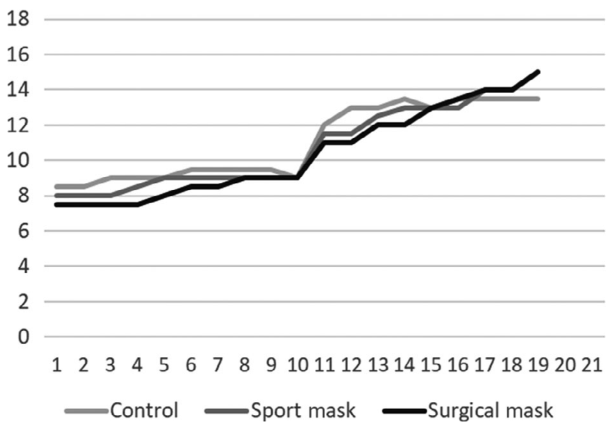

Fig. 7. Change in the values of the Borg scale in healthy young men during increased-intensity exercise while not wearing a mask (control), wearing a surgical mask, or wearing a mask for sport use. The value of the Borg scale, a scale of the rate of perceived exertion, did not differ between the intervention arms. There was no incidence of heatstroke, as defined by Japanese Association for Acute Medicine criteria.

significant difference was observed between the groups (median: control, 1.65 ng/ml; wearing surgical mask, 2.63 ng/ml and fabric sport mask, 2.16 ng/ml; $p = 0.87$; Figure 6).

Incidence of heatstroke and the Borg scale

Based on the JAAM-HS definition, there was no incidence of heatstroke. The average of the Borg scale did not differ among the three groups (median [Borg scale]: no mask, 13.5; surgical mask, 15; and sport mask, 15; Figure 7).

DISCUSSION

OUR STUDY PROVIDES evidence regarding the safety of wearing masks during intensity-controlled exercise under hot and humid conditions. There was no incidence of heatstroke, as defined by JAAM-HS criteria, and none of the participants had health problems. The value of the Borg scale, a scale of the rate of perceived exertion, did not differ between the intervention arms (i.e., control, wearing a surgical mask, and wearing a sport mask).

In this study, the temperature and humidity were controlled in an artificial weather room to create an environment conducive to heatstroke. Healthy young male volunteers were used in the experiment to investigate the physical effects of wearing a mask. To the best of our knowledge, this is the first study to evaluate the effects of wearing a mask in a hot environment on the body. We found similar results between mask-wearing and non-mask-wearing conditions regarding deep body temperature, vital signs, and dehydration level even in a hot environment set at WBGT of 28°C. When the physical load is strictly controlled, exercise can be undertaken safely while wearing a mask even in a hot environment, indicating that mask wearing is not a risk factor for exertional heatstroke.

Roberge et al. instructed healthy volunteers to perform exercise with low to moderate levels of exertion (5.6 km/h; 0° inclination) with and without surgical masks and measured changes in heart rate (9.5 b.p.m.) and respiratory rate (1.6 c.p.m.).[13] However, they did not strictly control the temperature or humidity of the laboratory, which were set at 21.5 °C and 23.1%, respectively (WBGT 15°C), which is considered similar to a normal environment. In this study, we created an artificial weather room to recreate an environment of 28°C WBGT, which could contribute to heatstroke; this allowed successful establishment of a situation similar to a real environment.

A previous study found no relationship between mask wearing and core body temperature increase in a normal temperature environment,[13] which is consistent with our finding of an increased risk of heatstroke in a hot and humid environment. Therefore, our study shows that wearing a mask is not a risk factor for heatstroke in a hot and humid environment, despite rest or exercise.

As stated earlier, Roberge et al.[13] found that wearing a surgical mask at a low to moderate exercise intensity resulted in increased heart and respiratory rates. In contrast, our study found no significant difference in body temperature or vital signs between the mask-wearing and non-mask-wearing groups. This finding could be attributed to the Karvonen method, which strictly controlled exercise intensity; furthermore, our study was undertaken with young healthy volunteers, who may have stronger physical compensatory mechanisms.

Another significant finding of our study is the examination of the effects of fabric masks on the body during exercise. The US Centers for Disease Control and Prevention guidelines recommend the use of fabric masks in addition to surgical masks.[14] In particular, multiple polyester masks have been recognized for their droplet control performance. Additionally, this study is significant to the current situation as it collected data regarding the current state of mask use in our country.

In this study, no significant difference was observed regarding the physical effects of wearing a surgical mask or a fabric mask. Few studies have evaluated the performance of fabric masks; however, so-called hybrid fabric masks made of multiple materials have been reported to have VFE of more than 80% and BFE of more than 90%,[15] which could indicate similar performance of surgical and fabric masks.

This study was unable to prove that mask wearing was a risk factor for heatstroke. However, we believe that this study accurately measured exercise load and body temperature; therefore, this indicates the safety of performing exercise while wearing a mask in a hot environment.

In this study, we used a capsule-type internal thermometer to measure the deep body temperature. A previous study has reported the usefulness of ingestive thermometers for monitoring body temperature.[16] In our study, it was possible to safely observe the deep body temperature for as long as 1 h. In future studies, we aim to use wearable devices and internal organs to measure heart rate and continuous body temperature to ensure the accuracy of measuring deep body temperature using the Karvonen method. This could be effective in preventing heatstroke while working and wearing a mask.

Limitations

This study has several limitations. First, the number of cases in this study had to be limited due to the human and environmental limitations of the COVID-19 pandemic. Therefore, the detection power might be weak. However, there were no significant differences in body size, muscle mass, or vital signs among the six patients, indicating similar characteristics between patients. Therefore, we believe that the data obtained were more accurate and uniform compared to a large cohort with diverse characteristics.

Second, the experiment was undertaken in the sequence of exercise without mask, then polyester mask, and finally surgical mask; therefore, the possibility of biases, including mental anxiety and tension, could occur. Additionally, there is the possibility that the body load was reduced due to heat acclimatization, or that it was affected by the physical condition of the day or the time of the experiment.

Finally, this experiment included only young men. Therefore, the results might not be applicable to women, the elderly, or children. It is necessary to also consider the effects of blood loss and basal body temperature in women who are menstruating. However, a higher incidence of heatstroke has been observed in male individuals worldwide,[17] and it can be said that we obtained practical data that address the current situation.

The elderly are at an increased risk for heatstroke.[1,2,18,] Therefore, further studies are necessary, particularly in monitoring exercise intensity.

CONCLUSION

WE USED AN artificial weather chamber to create a hot environment conducive to heatstroke. Using this environment, an experiment was undertaken to investigate the effects of mask wearing on the body in healthy young men. Wearing a mask by itself was not a risk factor for exertional heatstroke, and accurate monitoring of exercise intensity based on heart rate could have the potential to reduce the risk of heatstroke.

ACKNOWLEDGMENTS

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DISCLOSURE

APPROVAL OF THE research protocol: This research protocol was approved by the Institutional Review Board of Nippon Medical School (A-2020-029).

Informed consent: Statement of consent was obtained from all study participants.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None.

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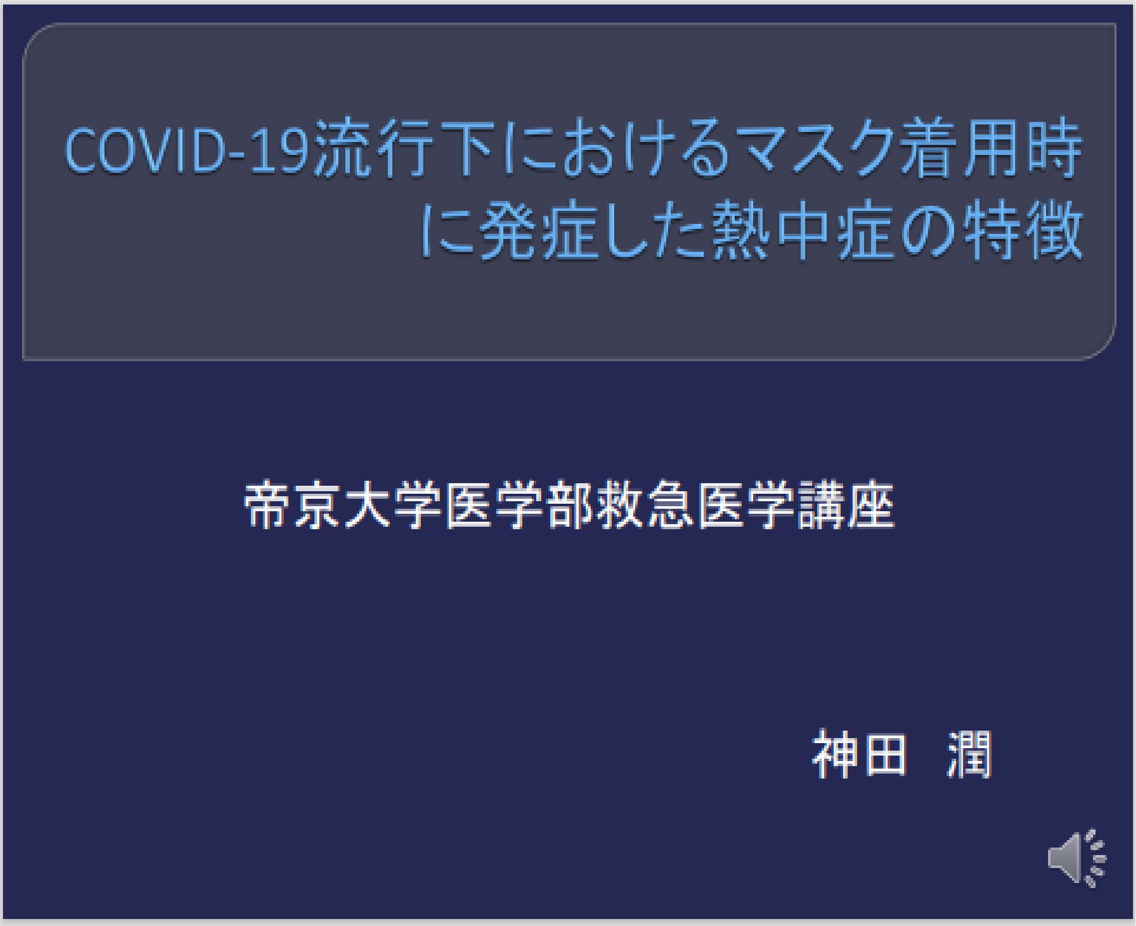
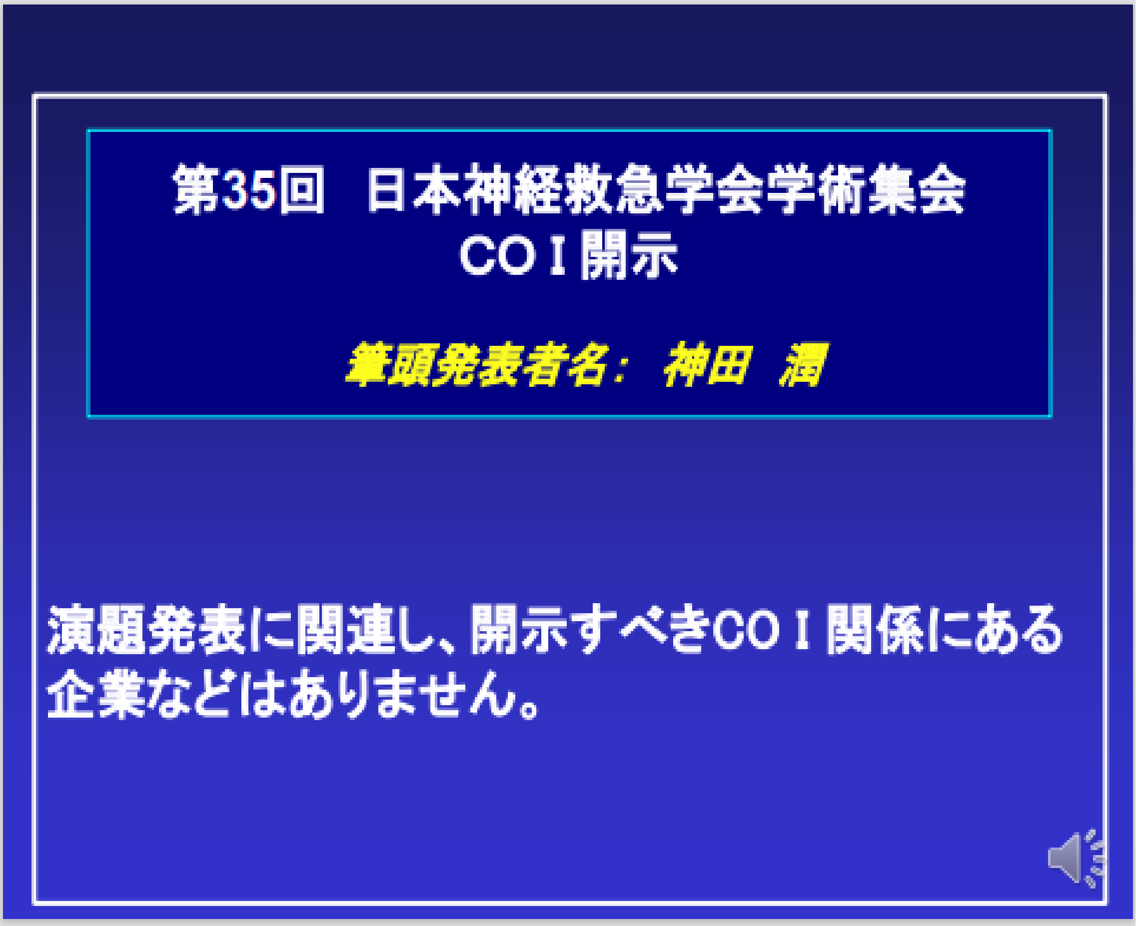
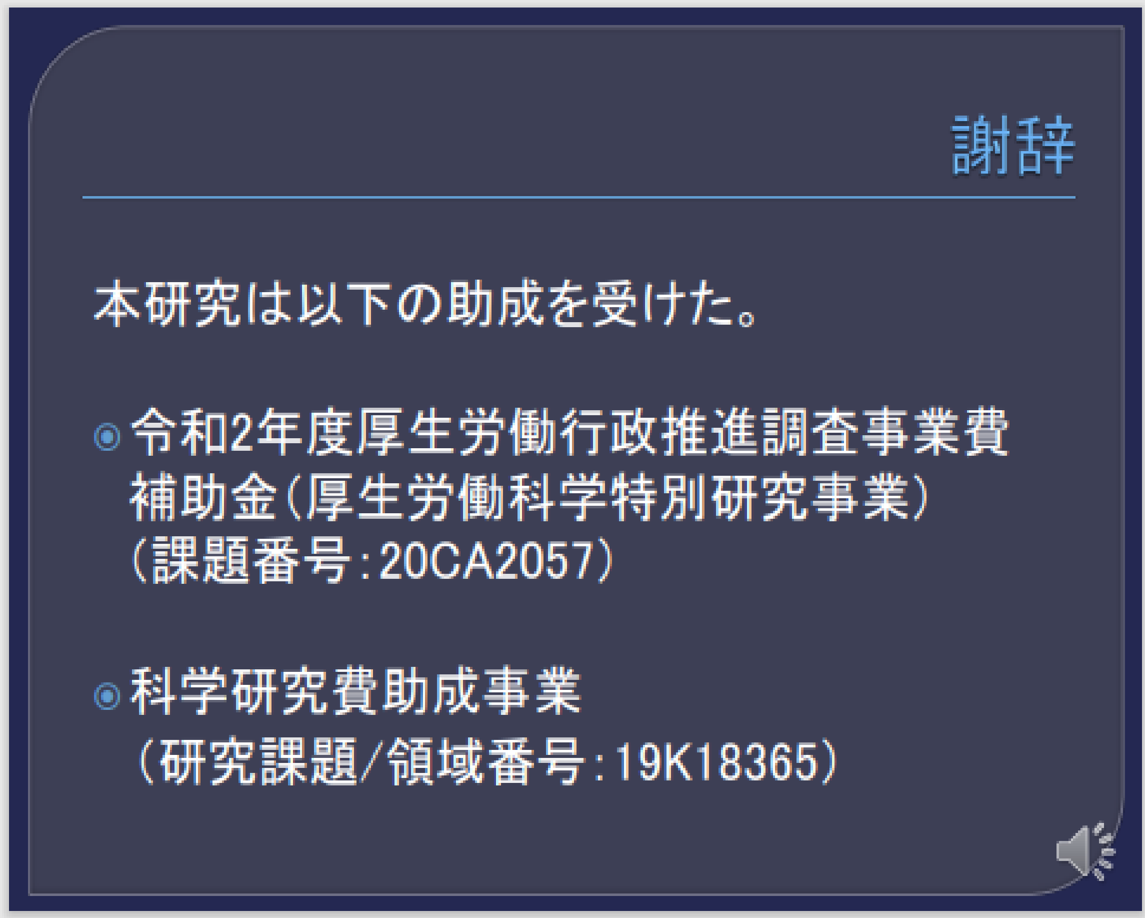

COVID-19流行下におけるマスク着用時に発症した熱中症の特徴
帝京大学医学部救急医学講座
神田　潤


第35回　日本神経救急学会学術集会
COＩ開示
筆頭発表者名：　神田　潤
演題発表に関連し、開示すべきCOＩ関係にある企業などはありません。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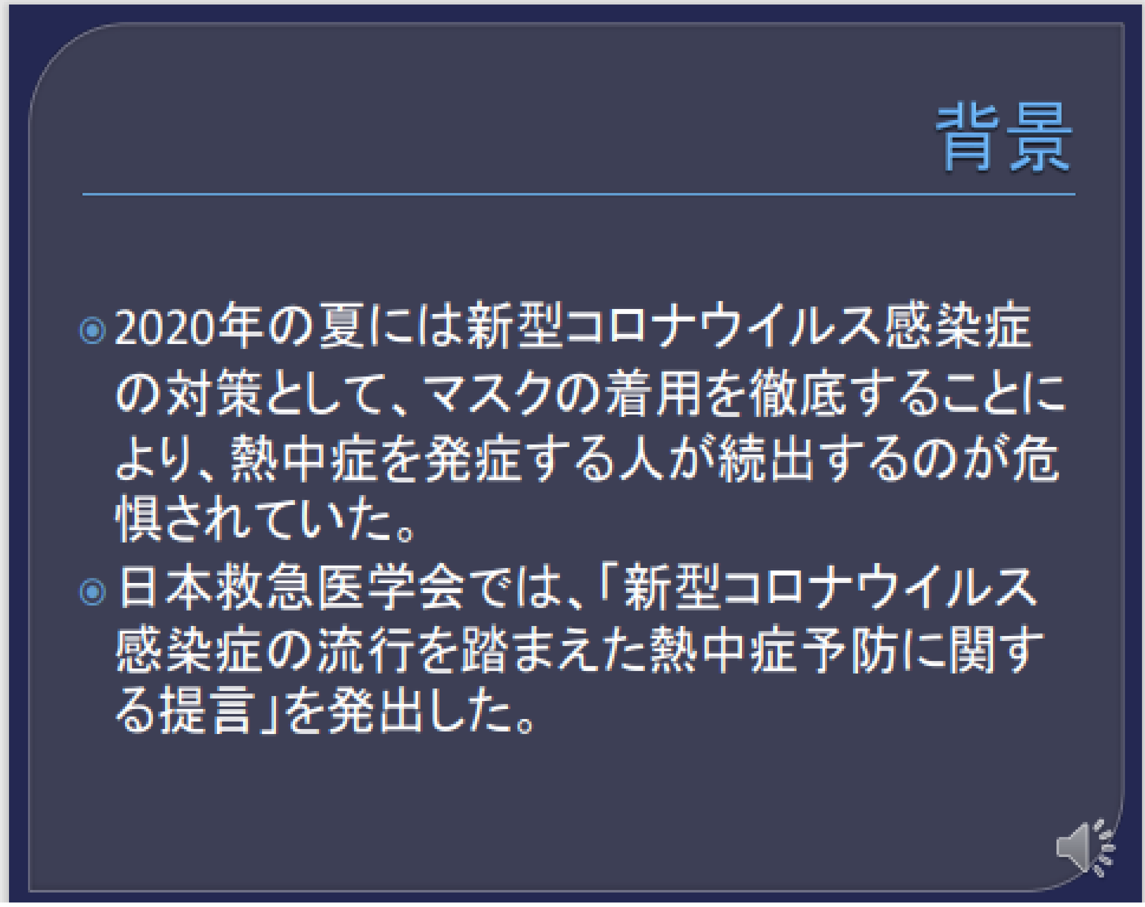
◎科学研究費助成事業（研究課題/領域番号：19K18365）


背景
◎2020年の夏には新型コロナウイルス感染症の対策として、マスクの着用を徹底することにより、熱中症を発症する人が続出するのが危惧されていた。
◎日本救急医学会では、「新型コロナウイルス感染症の流行を踏まえた熱中症予防に関する提言」を発出した。

「新型コロナウイルス感染症の流行を踏まえた熱中症予防に関する提言」

- 屋外においては、マスク着用により身体に負担がかかりますので，適宜マスクをはずして休憩することも大切です。
- ただし、感染対策上重要ですので，はずす際はフィジカル・ディスタンシング（密にならないこと）に配慮し、周囲環境等に十分に注意を払って下さい。

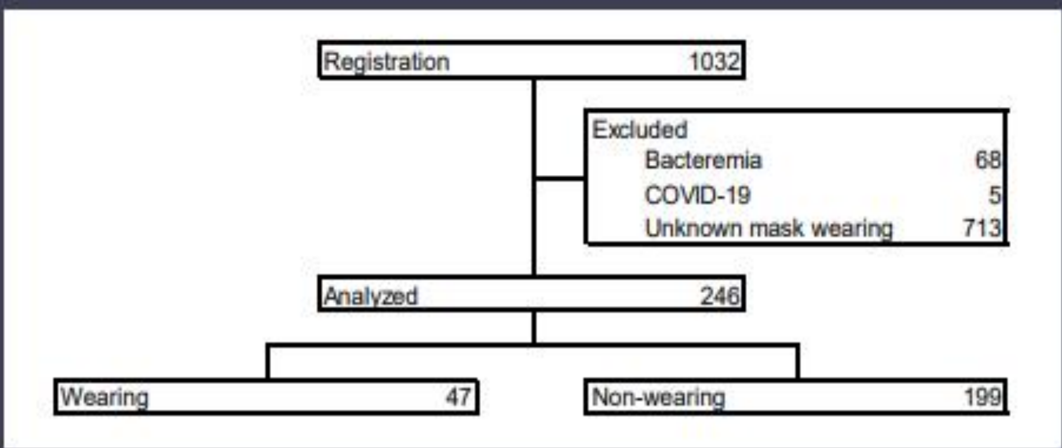
目的

- 新型コロナウイルス感染症流行下のマスク着用で発症した熱中症の特徴を明らかにする

方法

- 日本救急医学会が実施した熱中症疫学調査 Heatstroke STUDY 2020-21（142施設より1032症例が登録）の中間データを用いる。
- 熱中症発症時のマスク着用の有無と背景因子の関係（院内死亡、性別、年齢、BMI、発症機序、発症場所、深部体温、意識障害・肝障害・腎障害・DICの有無）について、クラメールの連関係数(V)を用いて分析した。
- V＞0.2を強い関係があるとみなす。

結果



結果

	Mask			
	Wearing (n=47)	Non-wearing (n=199)	V	p
	n (%)	n (%)		
In-hospital Deaths, No (%)	1(2.2)	21(11.6)	0.128	0.054
Unknown	1	18		
Male , No (%)	41(89.1)	131(66.2)	0.197	0.002
Unknown	1	1		
Age, years, No (%)			0.247	0.005
0-19	0(0.0)	19(9.5)		
20-39	6(12.8)	15(7.5)		
40-59	15(31.9)	29(14.6)		
60-79	16(34.0)	62(31.2)		
80+	10(21.3)	74(37.2)		
Unknown	0	0		

結果

	Mask			
	Wearing (n=47)	Non-wearing (n=199)	V	p
	n (%)	n (%)		
BMI, No (%)			0.157	0.102
-18.4	4(10.0)	34(23.6)		
18.5-24.9	20(50.0)	71(49.3)		
25.0+	16(40.0)	39(27.1)		
Unknown	7	55		
Onset situations, No (%)			0.415	0.000
Manual labor	28(59.6)	30(15.2)		
Sports	1(2.1)	25(12.7)		
Office work	0(0.0)	0(0.0)		
Everyday life	18(38.3)	142(72.1)		
Unknown	0	2		
Onset place, No (%)			0.338	0.000
Outdoor	36(76.6)	68(34.2)		
Indoor	11(23.4)	131(65.8)		
Unknown	0	0		

結果

	Mask			
	Wearing (n=47)	Non-wearing (n=199)	V	p
	n (%)	n (%)		
Deep temperature, centigrade, No (%)			0.160	0.437
42.0+	0(0.0)	2(2.3)		
40.0-41.9	4(22.2)	30(34.1)		
38.0-39.9	8(44.4)	40(45.5)		
-37.9	6(33.3)	16(18.2)		
Unknown	29	111		
Glasgow Coma Scale, No (%)			0.308	0.000
3-5	1(2.1)	36(18.4)		
6-8	2(4.3)	27(13.8)		
9-14	15(31.9)	79(40.3)		
15	29(61.7)	54(27.6)		
Unknown	0	3		

結果

	Mask			
	Wearing (n=47)	Non-wearing (n=199)	V	p
	n (%)	n (%)		
Liver damage, No (%)			0.113	0.081
Having liver damage	26(55.3)	132(68.8)		
Unknown	0	7		
Renal disfunction, No (%)			0.051	0.427
Having renal disfunction	41(89.1)	164(84.5)		
Unknown	1	5		
DIC, No (%)			0.185	0.010
Having DIC	3(7.3)	39(26.0)		
Unknown	6	49		

考察

- 「労働衛生と屋外活動でのマスク着用時の熱中症の予防」についての注意喚起をすることが重要である。
- 今後は労働やマスクの詳細を検討する必要がある。
- 除外症例（マスク着用の有無が不明）が多い。

結語

- 我が国の熱中症では高齢者の日常生活での発症が多いことが知られているが、マスク着用時の熱中症は肉体労働や屋外での発症が多いことが明らかになった。

COVID-19流行下における冷却（重症熱中症）の検討
－蒸散冷却法におけるエアロゾルの発生について－

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COVID-19流行下における冷却（重症熱中症）の検討
－蒸散冷却法におけるエアロゾルの発生について－

発表者のＣＯ Ｉ 開示

**演題発表に関連し、発表者らの開示すべき
COＩ関係にある企業等はありません。**

謝辞

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- 厚生労働行政推進調査事業「本邦における重症熱中症の実態把握に向けた研究（21LA2004)」（三宅班）より助成を受けた。
- 新日本空調株式会社ソリューション事業部より技術協力を受けた。

倫理

本研究は、帝京大学医学系研究倫理委員会で審査され、承認は不要と判断された。

背景

- COVID-19流行下における熱中症診療として、蒸散冷却法は体表面から水分が蒸発する際にエアロゾルを発生する危険が否定できない。
- 仮に、体表面がウイルスで汚染されていたら、エアロゾルが拡散することにより、感染拡大・クラスター発生の危険が大きくなることが懸念される。

背景

- 日本救急医学会など4学会は蒸散冷却法を実施せず、代替となる冷却法の実施を推奨した。

目的

- 蒸散冷却法により、体表面から水分が蒸発する際にエアロゾルをどの程度発生するのかを明らかにすることを目的とする。

方法

- 微粒子可視化システム（新日本空調株式会社製）により、クリーンルーム(同社施設）で静穏な状態を維持しながら、体表面温度を40℃に維持した人体模型に蒸散冷却法を行った。
- 概ね5μm以上の飛沫の飛散状況を可視化した。また、複数台のパーティクルカウンタを模擬ベッド周囲に配置して、蒸散冷却によるエアロゾル発生量を時系列で測定した。

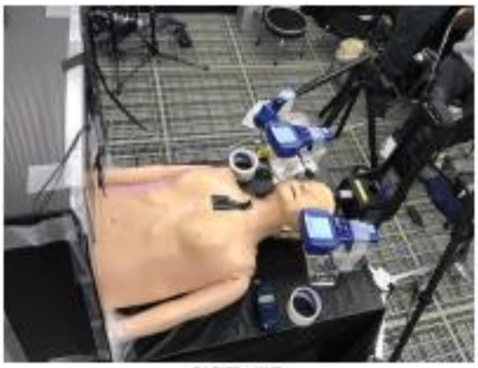
方法

- 人形表面温度は40°C、風速は2.5m/sec（扇風機相当）として、水分は微温湯(40°C) を吹きかけて、蒸散冷却を行った。

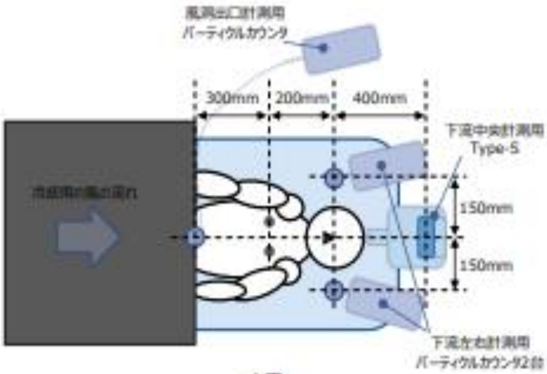
実験方法

2．粒子計数方法（人形胸元撮影時のみ）

人形胸元より気流上流側の粒子が無いことを確認するため、風洞の出口にパーティクルカウンタを1台設置する。胸元で蒸散した粒子を計測するため、気流下流側の左右にそれぞれパーティクルカウンタを設置し、中央に計測エリア（20cmx4cm）が大きいType-Sを設置する。パーティクルカウンタは3つの粒径レンジ（0.3~0.49μm、0.5~4.9μm、5.0μm以上）の個数濃度を計測し、Type-Sは0.5μm以上の粒子数を計測する。



計測器の様子



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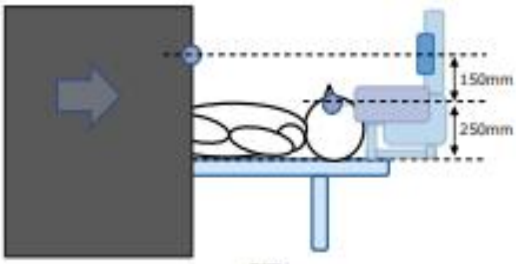


側面

実験方法

3．人形表面温度の制御方法

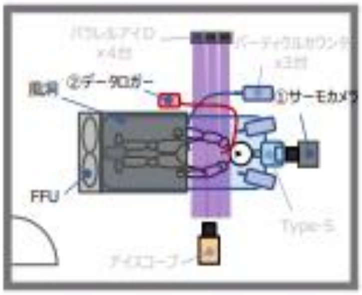
人形胸元カバーの裏側にラバーヒーター（面ヒーター）を貼り付け、投入電圧を調整することで表面温度の制御を行った。

胸元カバー裏側の様子

ラバーヒーター

4．人形表面温度の測定方法

①サーモカメラで人形の上半身の様子を撮影し、②データロガーで胸元の1点をピンポイント計測した。実験ではデータロガーの温度データを人形表面温度とした。



①サーモカメラ

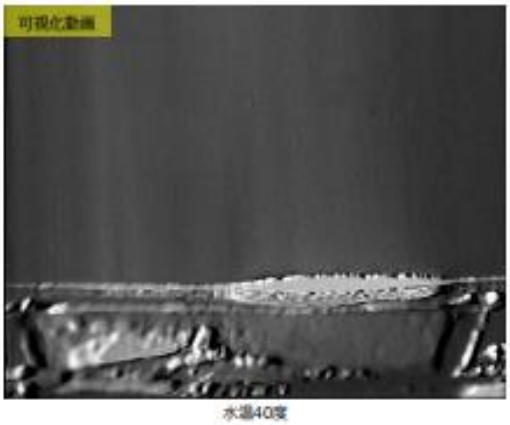
②データロガー（T熱電対）

結果 (参考,予備実験) 水道水40度,80度の蒸散の様子

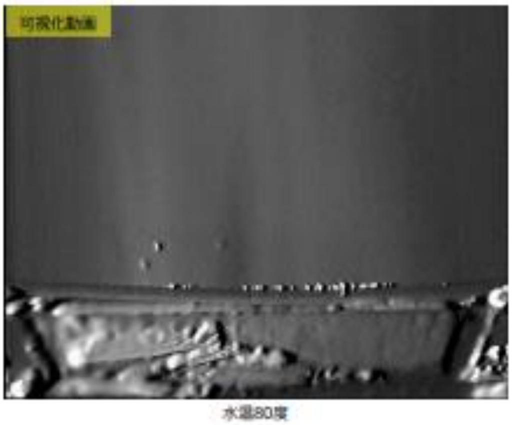
ステンレスバット

ステンレスバットに40度,80度の水道水を入れて蒸散する様子があるか確認した。
（撮影開始とともに蓋を外した。室温19度/80%(RH)）

⇒80度のお湯が大量にある状態（簡単に冷えない状態）だと顕著な粒子の発生が確認できる。
一方40度の場合は少量の粒子しか発生していないことが確認できる。



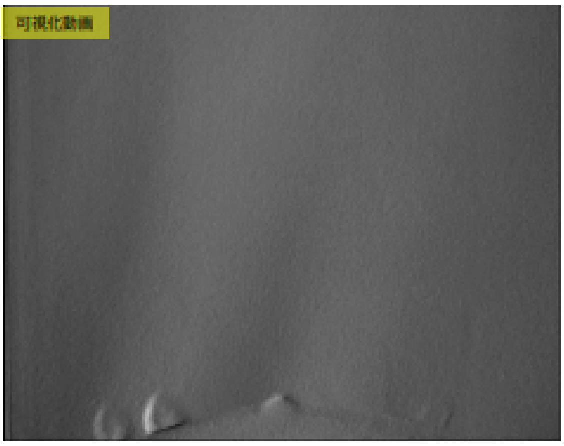
水温40度

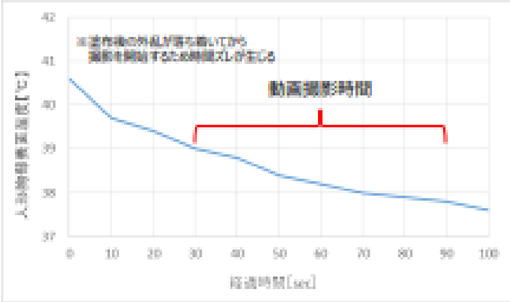


水温80度

結果 生理食塩水40度_人形表面温度40度_冷却風速2.5m/s_可視化データ

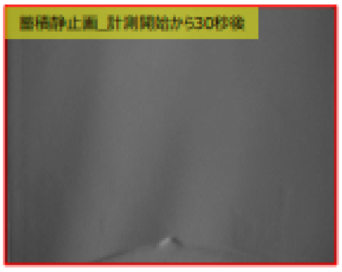
※撮影（測定）時間は、人形表面温度が約40度から38度まで低下した時間とする=約1分

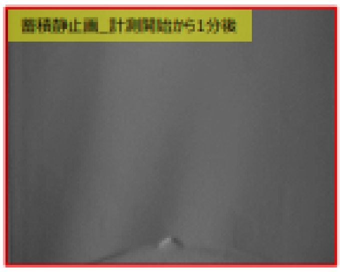




人形胸元のピンポイント温度データ

※蓄積静止画=映像を蓄積させた静止画のことで、
今回は計測開始後の任意の経過時間後の約1秒間の動画を蓄積した





結果

- 人形表面温度は40°C
- 風速は2.5m/sec（扇風機相当）
- 微温湯(40°C) を吹きかけた場合

- 人形表面温度が低下して、蒸散冷却の効果をみとめた。
- エアロゾルの発生はなかった。

考察

- 水分の蒸発に伴うエアロゾル発生は、80℃程度の高温環境下で認められる現象であり、熱中症患者の40℃程度では、水分の蒸発に伴う気化熱の消費により蒸散冷却を行ったとしても、エアロゾルは発生しない。
- 蒸散冷却法自体による感染のリスクはないと考えられる。

考察

- しかし、COVID-19が否定できない熱中症患者に対して、蒸散冷却法を行う場合は、冷却法自体のリスクはなくとも、会話や咳などにより飛沫を通じた感染のリスクは残存する。
- 医療従事者は厳重な感染対策を行いながら処置を行うことに変わりはない。

結語

- 熱中症患者への蒸散冷却法は、エアロゾルを発生させず、厳重な感染対策を行えば、感染拡大・クラスター発生の危険は少ない。

資料 6

マスク着用時に発症した熱中症の特徴と
エアロゾルを介した蒸散冷却のリスク

帝京大学医学部　救急医学講座
日本救急医学会
熱中症および低体温症に関する委員会

神田　潤

マスク着用時に発症した熱中症の特徴と
エアロゾルを介した蒸散冷却のリスク

発表者のＣＯ Ｉ 開示

演題発表に関連し、発表者らの開示すべき
COＩ関係にある企業等はありません。

謝辞

以下の助成を受けた。

- 科学研究費助成事業

  （19K18365）

- 風に立つライオン基金

  （熱中症関連疾患に関する多国籍共同研究グループ）

背景・目的

- COVID-19渦での熱中症の主な論点は、マスク着用時の熱中症対策と蒸散冷却を実施した際のエアロゾル発生の2点である。
- マスク着用時に発症した熱中症の特徴とエアロゾルを介した蒸散冷却のリスクを明らかにする。

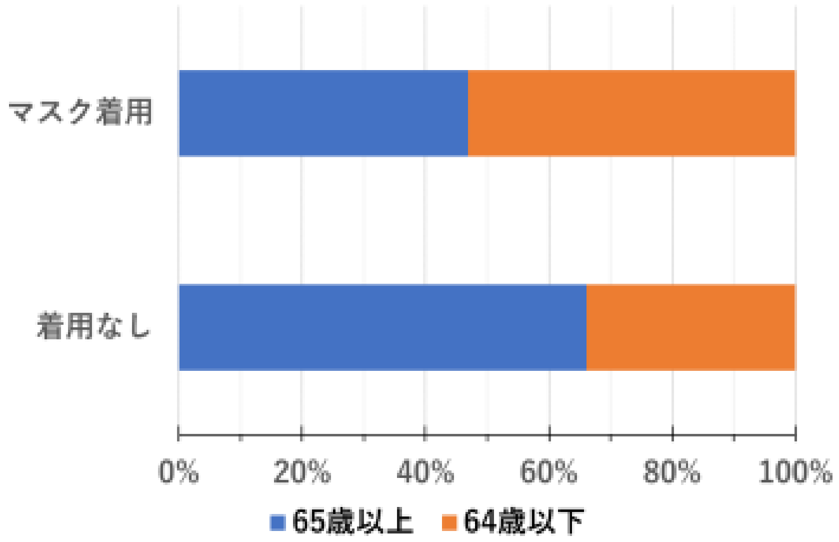
マスク着用時に発症した熱中症の特徴

- 日本救急医学会熱中症および低体温症に関する委員会が実施したHeat stroke STUDY2020のデータを用いて検討した。
- 全国の救命救急センター、専門医施設143施設より、熱中症と診断されて、初期診療を受けた入院患者1032症例が登録された。

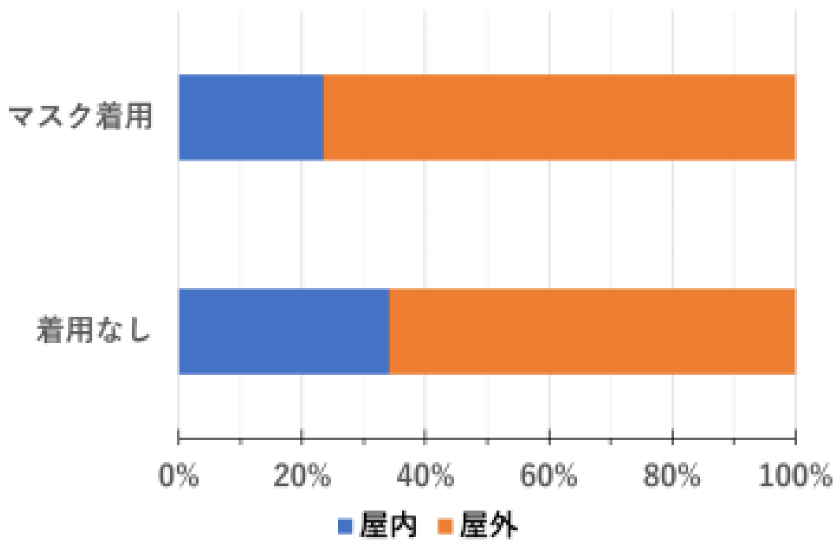
方法

- 参加各施設の倫理委員会より承認を得た。
- 転帰、性別、年齢、発生状況、発生場所、体温、意識、脈拍、心拍、呼吸数などの診療情報を各施設がWebで登録した。
- 各項目の不明例を除外した上で、マスク着用の有無で、年齢、発生状況、発生場所、重症度を比較した。

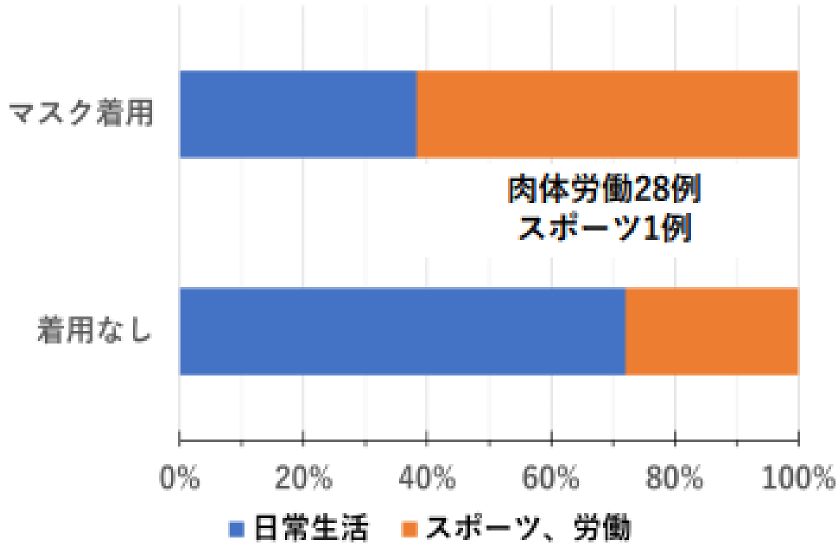
マスク着用
年齢：64歳以下26例(53.1%)



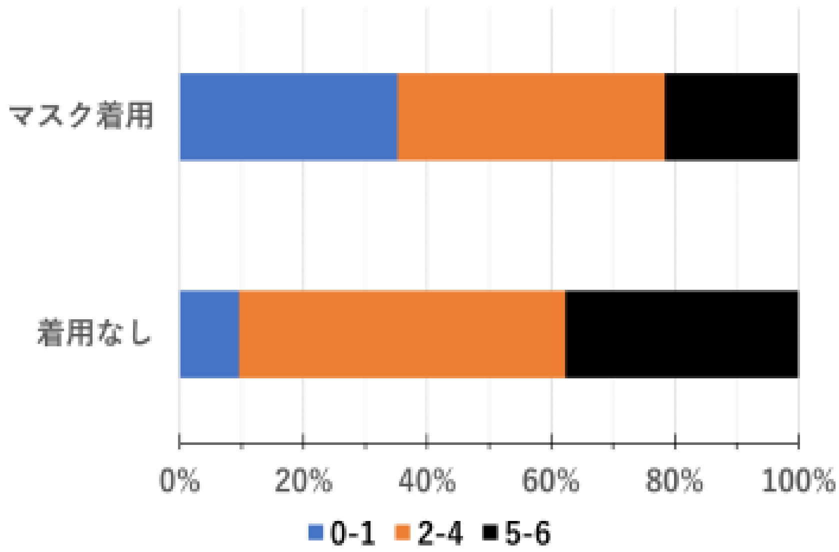
マスク着用
発生場所：屋外36例（76.6%）



マスク着用
発生状況：スポーツ・労働29例(61.7%)



マスク着用：J-ERATOスコア
0-1点：13例(35.1%)



結果

- マスク着用では、肉体労働、屋外、若年者の発症、軽症例が多かった。(V >0.2 , $p < 0.05$)。

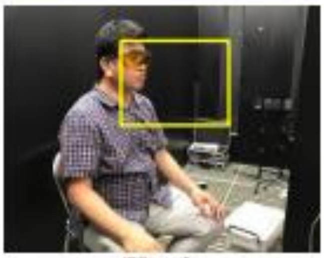
考察

- マスク着用時は肉体労働・スポーツ、屋外での発症が多く、熱中症予防と感染対策の両立には、適切なマスクの着脱が重要である。

エアロゾルを介した蒸散冷却のリスク

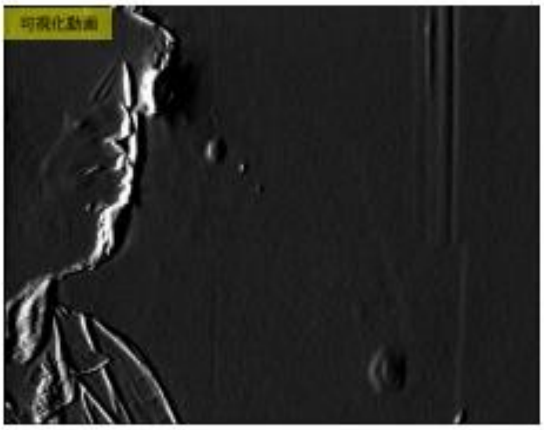
- 微粒子可視化システム（新日本空調）により、クリーンルームで静穏な状態を維持した。
- 体表面温度を40°Cに維持した人体模型に蒸散冷却法を行い、概ね5μm以上の飛沫の飛散状況を可視化した。

(参考,予備実験) 発声の様子



撮影アングル

⇒発声することで、飛沫が発生している様子が確認できる。

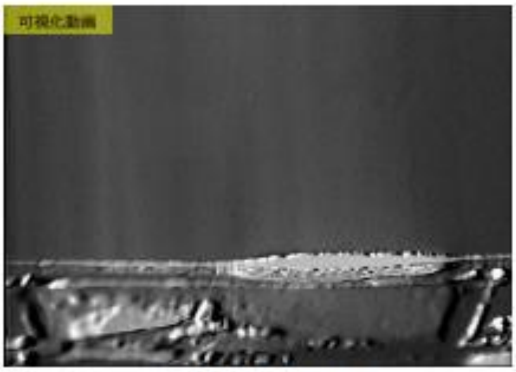


(参考,予備実験) 水道水40度,80度の蒸散の様子

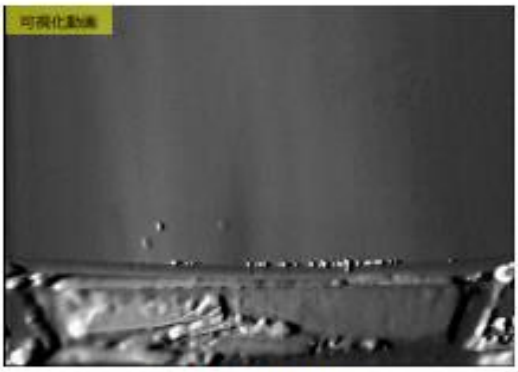
ステンレスバット

ステンレスバットに40度,80度の水道水を入れて蒸散する様子があるか確認した。
（撮影開始とともに蓋を外した。室温19度/80%(RH)）

⇒80度のお湯が大量にある状態（簡単に冷えない状態）だと顕著な粒子の発生が確認できる。
一方40度の場合は少量の粒子しか発生していないことが確認できる。



水温40度

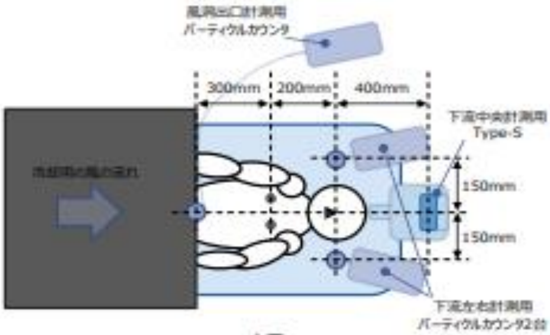


水温80度

実験方法

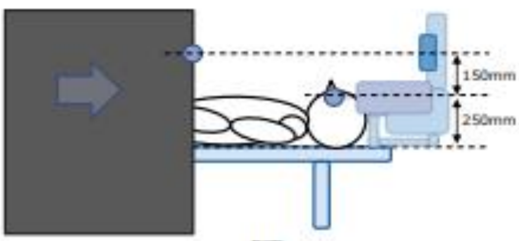
粒子計数方法（人形胸元撮影時のみ）

人形胸元より気流上流側の粒子が無いことを確認するため、風洞の出口にパーティクルカウンタを1台設置する。胸元で蒸散した粒子を計測するため、気流下流側の左右にそれぞれパーティクルカウンタを設置し、中央に計測エリア（20cmx4cm）が大きいType-Sを設置する。パーティクルカウンタは3つの粒径レンジ（0.3~0.49μm、0.5~4.9μm、5.0μm以上）の個数濃度を計測し、Type-Sは0.5μm以上の粒子数を計測する。

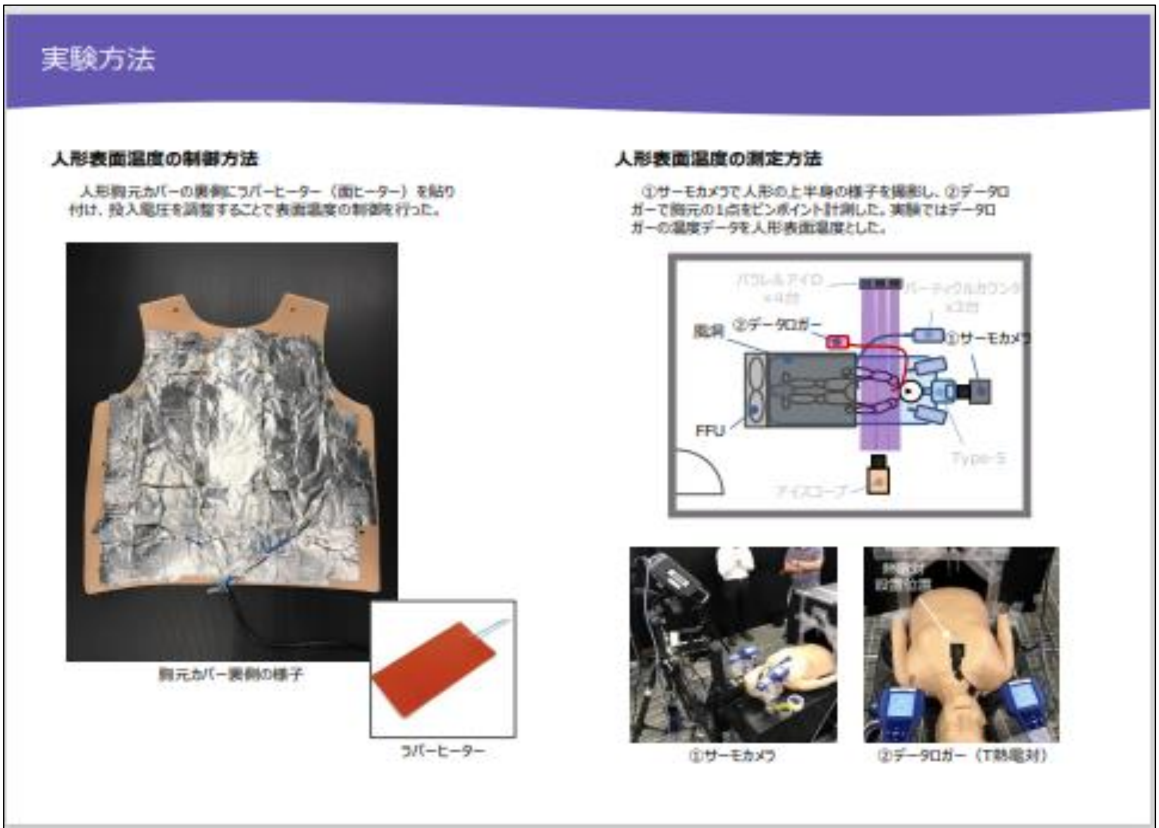


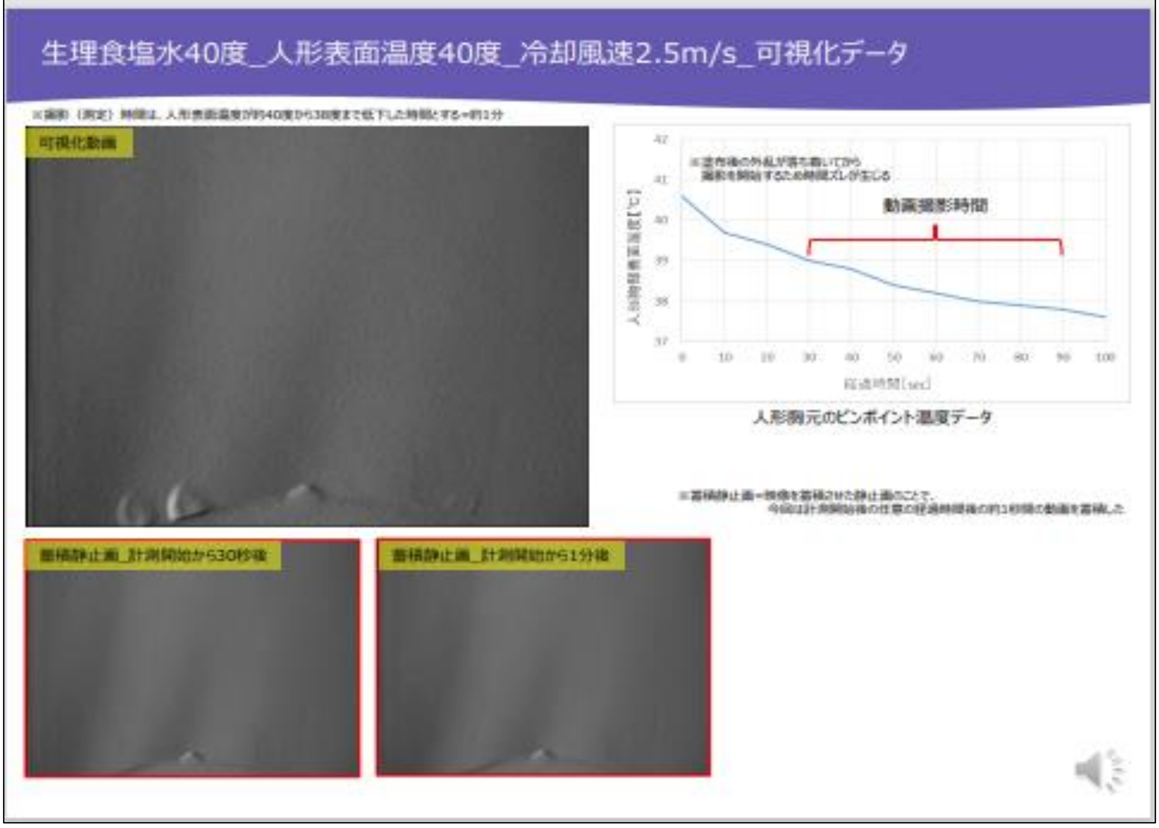
上面

計測器の様子



側面


実験方法
人形表面温度の制御方法
人形胸元カバーの裏側にラバーヒーター（面ヒーター）を貼り付け、投入電圧を調整することで表面温度の制御を行った。
胸元カバー裏側の様子
ラバーヒーター
人形表面温度の測定方法
①サーモカメラで人形の上半身の様子を撮影し、②データロガーで胸元の1点をピンポイント計測した。実験ではデータロガーの温度データを人形表面温度とした。
風洞
②データロガー
①サーモカメラ
FFU
①サーモカメラ
②データロガー（T熱電対）


生理食塩水40度_人形表面温度40度_冷却風速2.5m/s_可視化データ
可視化動画
動画撮影時間
42
41
40
39
38
37
0
10
20
30
40
50
60
70
80
90
100
人形胸元のピンポイント温度データ
蓄積静止画_計測開始から30秒後
蓄積静止画_計測開始から1分後

結果

- 人形表面温度40°Cに対して、風速2.5ml/hr（扇風機相当）、水温40°C（微温湯）での蒸散冷却を行うと、人形の表面温度が低下して、蒸散冷却の効果をみとめたが、エアロゾルの発生はなかった。

考察

- 蒸散冷却法自体によるエアロゾルを介した感染のリスクはない。
- しかし、会話や咳などによる感染のリスクは残存するので、感染対策は継続する必要がある。

結語

- マスク着用時は肉体労働・スポーツ、屋外での発症が多く、熱中症予防と感染対策の両立には、適切なマスクの着脱が重要である。
- 蒸散冷却法自体によるエアロゾルを介した感染のリスクはない。
- しかし、会話や咳などによる感染のリスクは残存するので、感染対策は継続する必要がある。

Differences in heat stroke prevention between Japan and Southeast Asia

Teikyo university
Heatstroke and hypothermia surveillance committee
of Japan association for acute medicine

Jun Kanda

Acknowledgments

- I am supported by KAKENHI and The Lion Standing Against the Wind Fund Foundation.

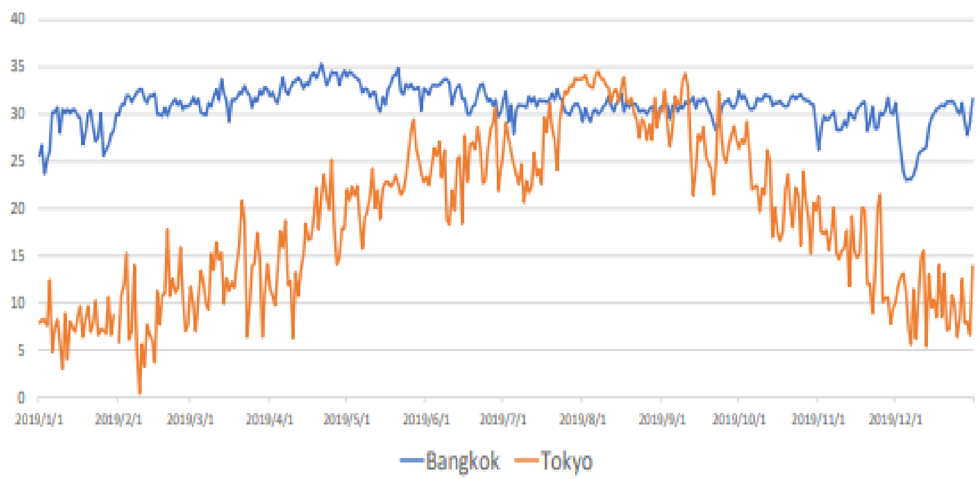
Background

- Recent reviews have highlighted global warming and health impacts in tropical areas.
- Global warming will increase heat illness at home, work and sports.

Characteristics of Japan

- Japan has a temperate humid climate with four distinct seasons.
- The temperature range throughout the year is wide, and temperatures can exceed 35 °C in the summer.
- Japan was the world's most aged population in 2017 (27.7% were ≥65 years old).

Highest temperature of Bangkok and Tokyo in 2019



The difference between Bangkok and Tokyo

- The both highest temperature of August exceeds 30°C and it is very hot.
- There is greatly a difference of the temperature of winter.

Heat stroke in Japan

- In Japan, more than 50,000 heat illness patients are transported to hospital by ambulance from May to September every year.
- A total of 95,137 patients were transported to hospitals for heat stroke, and 160 ultimately died in 2018.
- It has been reported that the majority of severe heatstroke cases were in elderly subjects affected during daily activities.

Definitions about heat stroke

- Because definitions of Heatstroke, heat illness, heat exhaustion and Heat related illness are not unified, we confuse and use them.
- In this report, we define them according to the general article of Bouchama A from N Engl J Med.

Bouchama A, Knochel JP. Heat stroke. N Engl J Med. 2002;346(25):1978-88.

Heat stroke

Severe illness characterized by a core temperature >40° C and central nervous system abnormalities such as delirium, convulsions, or coma resulting from exposure to environmental heat (classic heat stroke) or strenuous physical exercise (exertional heat stroke)

Bouchama A, Knochel JP. Heat stroke. N Engl J Med. 2002;346(25):1978-88.

Active Cooling

- Active cooling is essential for the treatment of heat stroke (Severe; deep body temperature ≧40°C and Glasgow coma scale ≦8) .
- In multivariate analysis, Rehydration-only therapy had a 3.29-fold higher risk of in-hospital mortality than Active cooling.

Kanda J, Nakahara S, Nakamura S, et al. Association between active cooling and lower mortality among patients with heat stroke and heat exhaustion. PLoS One. 2021; 16 (11): e0259441.

Heat illness

- **All illness** from exposure to high environmental heat or strenuous physical exercise

- Heatstroke(Severe) + Heat exhaustion(Mild to moderate)

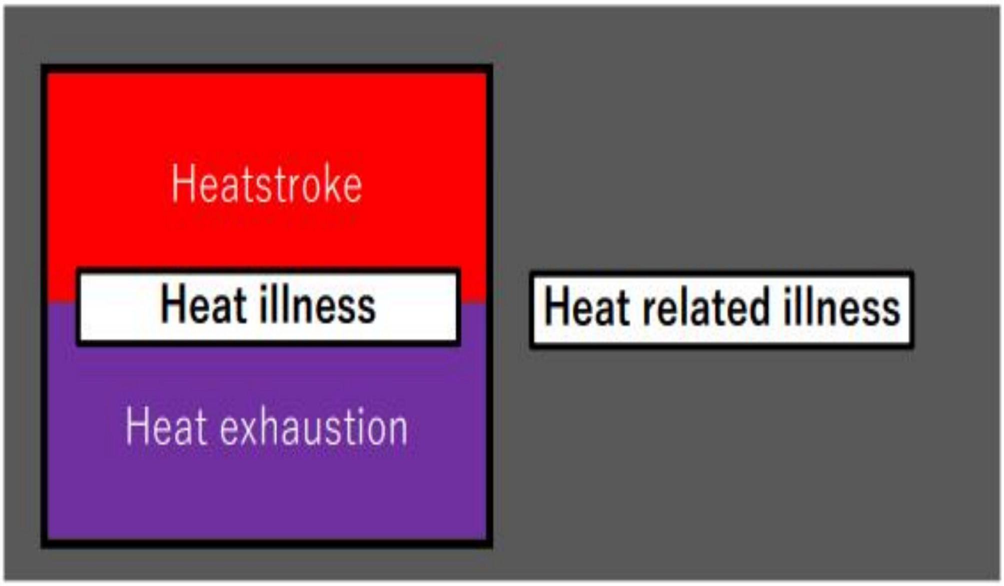
Heat related illness

- Illness from exposure to high environmental heat or strenuous physical exercise but **not to have a diagnosis of heat illness**

- The border with heat illness is indistinct.

- In the heat environment Heat related illness may increase before Heat illness increases.

Physical disability due to heat environment



Examples of Heat related illness

- In the previous research, the onset of the following disease increases by a rise in temperature.
  - Psychiatric disorders
  - Heart conduction disorders
  - Cerebrovascular disorder
  - Kidney disease

Worries about Heat related illness

- Because heat stroke has not been diagnosed, is there a risk that Active Cooling is not being performed on patients who need it?

Limitations of the previous research

- They do not examine a climate and a disease outbreak directly.
- They do not consider a local difference.
- The definition of heat illness and heat related illness is not clear.

The relation between heat related illness and climate: multi-country study

- We plan to determine disease included in heat related illness by revealing relations of climate (especially temperature and humidity) and onset of every disease.
- If the details of Heat related illness are determined, we can prevent heat illness and heat related illness more effectively.

Subject

- All patients of emergency visit in cooperation institutions between 1st January and 31 December 2019.
- I'm assuming a total of 400,000 people (currently collecting data)

Cooperative institutions (4countries 10 institutions)

- Teikyo University (Tokyo, Japan)
- Khon Kaen hospital (Thailand)
- Mahidol University (Thailand)
- Mahosot hospital (Laos)
- Hanoi medical university (Vietnam)
- Aizawa hospital(Cool area of Japan)
- Asahi general hospital (Cool area of Japan)
- Ageo Central General Hospital(Hot area of Japan)
- Northern Okinwa Medical Center (Hot area of Japan)

Methods

- Each institution will send the following patient information to us.

  ① Date ②Age ③Sex ④Disease name (ICD-10)

- We will obtain weather information of each area through Japan Meteorological Business Support Center.

- We will match patient information with weather information and examine a relationship.

Intermediate analysis

- We performed an interim analysis using the data we have now collected.
- We calculated the correlation between WBGT and the number of heat stroke visits for each day at each hospital.

Correlation coefficient between the number of heat stroke cases and temperature (interim analysis)

	Total	Heat stroke	Correlation coefficient	*p*
Japan				
Asahi General Hospital	30,179	131(0.43%)	0.420	<0.001
Aizawa Hospital	29,336	79(0.27%)	0.412	<0.001
Ageo Central General Hospital	4,104	23(0.56%)	0.340	<0.001
Teikyo University	2,197	27(1.22%)	0.183	<0.001
Southeast Asia				
Koan Kaen Hospital	114,561	28(0.024%)	0.095	0.07
Hanoi Medical University	22,361	5(0.024%)	0.252	<0.001

Summary of Interim analysis

- In Japan, heat stroke patients accounted for about 0.5-1.0% of all patients and were correlated with WBGT.

- In Southeast Asia, heat stroke patients accounted for only about 0.02% of all patients, and some facilities did not correlate with WBGT.

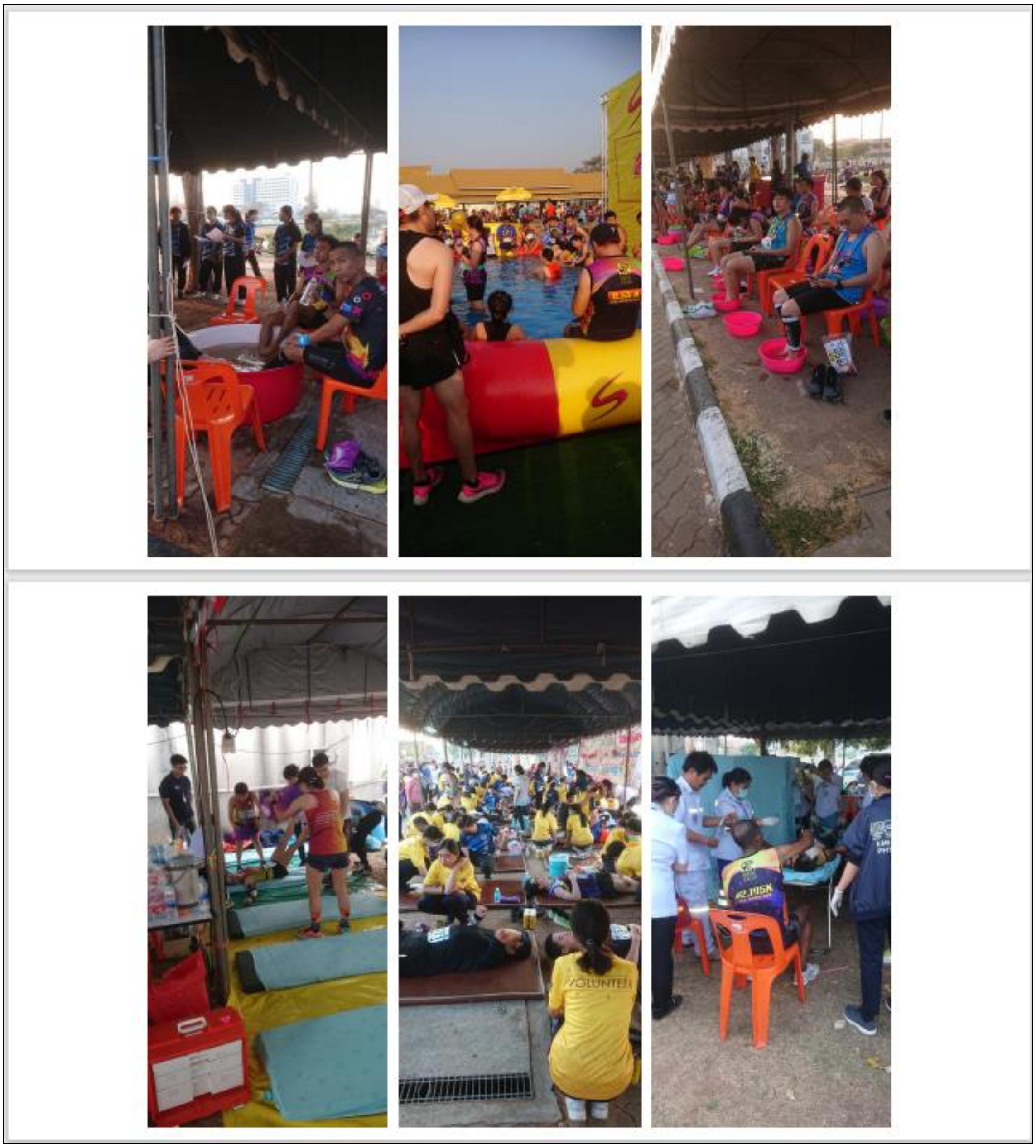
Consideration

- In the case of heat-related illness, which is a complication of heat stroke, treatment of both heat stroke and other illnesses will be necessary, but it is necessary to examine whether treatment of other illnesses in Japan and heat stroke in Southeast Asia is lagging behind.

- In this study, Heat related illnesses will be identified by examining which diseases are increasing in number with increasing WBGT.

Especially in sports

- In sports, people who are healthy by nature are prone to heat stroke, so this is not a situation where other diseases should be considered.
- Active cooling and fluid intake, which is the initial treatment for heat stroke, should be given as soon as possible.
- I will report on my visit to the Khon Kaen Marathon in January 2020.



Report

- Active Cooling (Cold water immersion) is being implemented.
- There was a noticeable number of cases of massage without cooling, and several of these cases were severe.

Consideration

- Although we cannot deny the possibility of orthopedic injuries, we believe that many of these cases are due to cramps as a symptom of heat stroke.
- As in the emergency room, it is likely that there are injured people in sports who are not recognized as having heat stroke.
- It is important to reduce the number of cases of serious illness due to lack of prompt active cooling and hydration.

Objection

- In Southeast Asia, people have a well-established lifestyle against the heat, and heat stroke is less common.
- If this opinion is correct, then Japan needs to learn a lot from Southeast Asia.
- In any case, it would be beneficial for Southeast Asia and Japan to work together to promote measures against heat stroke.

Conclusion

- If heat stroke is missed, there is a risk of delay in active cooling, so it is important to be proactive in the differential diagnosis.
- Especially in sports, it is important to take measures against heat stroke because many people are healthy by nature.

Ⅱ．研究成果の刊行に関する一覧表

研究成果の刊行に関する一覧表

雑誌

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
Kanda J, Nakahara S, Nakamura S, et al.	Association between active cooling and lower mortality among patients with heatstroke and heat exhaustion.	PLoS One.	16 (11)	e0259441	2021
Kanda J, Miyake Y, Umehara T, et al.	Influence of the coronavirus disease 2019 (COVID-19) pandemic on the incidence of heat stroke and heat exhaustion in Japan: a nationwide observational study based on the Heatstroke STUDY 2019 (without COVID-19) and 2020 (with COVID-19).	Acute Medicine & Surgery	9 (1)	e731.	2022
Taigo Sakamoto	Wearing a mask during controlled exercise intensity is not a risk factor of exertional heatstroke: A pilot study.	Acute Medicine & Surgery	8	e712	2021

厚生労働行政推進調査事業費補助金
（健康安全・危機管理対策総合研究事業）

『新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

令和３年度　総括研究報告書

研究代表者 横堀　將司（日本医科大学大学院医学研究科救急医学分野）
東京都文京区千駄木 1-1-5　Tel. 03-3822-2131

令和４年４月１５日

厚生労働大臣　殿

機関名　　日本医科大学

所属研究機関長　職　名　　学長

氏　名　　弦間　昭彦

次の職員の令和３年度厚生労働行政推進調査事業費の調査研究における、倫理審査状況及び利益相反等の管理については以下のとおりです。

１．研究事業名　　健康安全・危機管理対策総合研究事業

２．研究課題名　　『新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

３．研究者名　（所属部署・職名）　大学院医学研究科　・　教授

（氏名・フリガナ）　横堀　將司　・　ヨコボリ　ショウジ

４．倫理審査の状況

	該当性の有無		左記で該当がある場合のみ記入（※1）		
	有	無	審査済み	審査した機関	未審査（※2）
人を対象とする生命科学･医学系研究に関する倫理指針（※3）	■	□	■	日本医科大学	□
遺伝子治療等臨床研究に関する指針	□	■	□		□
厚生労働省の所管する実施機関における動物実験等の実施に関する基本指針	□	■	□		□
その他、該当する倫理指針があれば記入すること（指針の名称：　）	□	■	□		□

（※1）当該研究者が当該研究を実施するに当たり遵守すべき倫理指針に関する倫理委員会の審査が済んでいる場合は、「審査済み」にチェックし一部若しくは全部の審査が完了していない場合は、「未審査」にチェックすること。

その他（特記事項）

（※2）未審査に場合は、その理由を記載すること。
（※3）廃止前の「疫学研究に関する倫理指針」、「臨床研究に関する倫理指針」、「ヒトゲノム・遺伝子解析研究に関する倫理指針」、「人を対象とする医学系研究に関する倫理指針」に準拠する場合は、当該項目に記入すること。

５．厚生労働分野の研究活動における不正行為への対応について

研究倫理教育の受講状況	受講 ■　未受講 □

６．利益相反の管理

当研究機関におけるＣＯＩの管理に関する規定の策定	有 ■　無 □（無の場合はその理由：　）
当研究機関におけるＣＯＩ委員会設置の有無	有 ■　無 □（無の場合は委託先機関：　）
当研究に係るＣＯＩについての報告・審査の有無	有 ■　無 □（無の場合はその理由：　）
当研究に係るＣＯＩについての指導・管理の有無	有 □　無 ■（有の場合はその内容：　）

（留意事項）　・該当する□にチェックを入れること。
・分担研究者の所属する機関の長も作成すること。

令和　４　年　４　月　２７　日

厚生労働大臣　殿

機関名　　帝京大学

所属研究機関長　職　名　　学　　長

氏　名　　冲永　佳史

次の職員の令和３年度厚生労働行政推進調査事業費の調査研究における、倫理審査状況及び利益相反等の管理については以下のとおりです。

１．研究事業名　　健康安全・危機管理対策総合研究事業

２．研究課題名　　『新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

３．研究者名　（所属部署・職名）　医学部救急医学講座・講師

（氏名・フリガナ）　神田　潤（カンダ　ジュン）

４．倫理審査の状況

	該当性の有無		左記で該当がある場合のみ記入（※1）		
	有	無	審査済み	審査した機関	未審査（※2）
人を対象とする生命科学･医学系研究に関する倫理指針（※3）	□	■	□		□
遺伝子治療等臨床研究に関する指針	□	■	□		□
厚生労働省の所管する実施機関における動物実験等の実施に関する基本指針	□	■	□		□
その他、該当する倫理指針があれば記入すること（指針の名称：　）	□	■	□		□

（※1）当該研究者が当該研究を実施するに当たり遵守すべき倫理指針に関する倫理委員会の審査が済んでいる場合は、「審査済み」にチェックし一部若しくは全部の審査が完了していない場合は、「未審査」にチェックすること。

その他（特記事項）

（※2）未審査に場合は、その理由を記載すること。
（※3）廃止前の「疫学研究に関する倫理指針」、「臨床研究に関する倫理指針」、「ヒトゲノム・遺伝子解析研究に関する倫理指針」、「人を対象とする医学系研究に関する倫理指針」に準拠する場合は、当該項目に記入すること。

５．厚生労働分野の研究活動における不正行為への対応について

研究倫理教育の受講状況	受講 ■　　未受講 □

６．利益相反の管理

当研究機関におけるＣＯＩの管理に関する規定の策定	有 ■　無 □(無の場合はその理由:　)
当研究機関におけるＣＯＩ委員会設置の有無	有 ■　無 □(無の場合は委託先機関:　)
当研究に係るＣＯＩについての報告・審査の有無	有 ■　無 □(無の場合はその理由:　)
当研究に係るＣＯＩについての指導・管理の有無	有 □　無 ■（有の場合はその内容：　）

（留意事項）　・該当する□にチェックを入れること。
・分担研究者の所属する機関の長も作成すること。

令和 4 年 3 月 11 日

厚生労働大臣　殿

機関名　日本体育大学

所属研究機関長　職　名　学長

氏　名　石井　隆憲

次の職員の令和３年度厚生労働行政推進調査事業費の調査研究における、倫理審査状況及び利益相反等の管理については以下のとおりです。

１．研究事業名　健康安全・危機管理対策総合研究事業

２．研究課題名　『新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

３．研究者名　（所属部署・職名）　日本体育大学　保健医療学部・准教授

（氏名・フリガナ）　鈴木　健介・スズキ　ケンスケ

４．倫理審査の状況

	該当性の有無		左記で該当がある場合のみ記入（※1）		
	有	無	審査済み	審査した機関	未審査（※2）
人を対象とする生命科学･医学系研究に関する倫理指針（※3）	□	■	□		□
遺伝子治療等臨床研究に関する指針	□	■	□		□
厚生労働省の所管する実施機関における動物実験等の実施に関する基本指針	□	■	□		□
その他、該当する倫理指針があれば記入すること（指針の名称：　）	□	■	□		□

（※1）当該研究者が当該研究を実施するに当たり遵守すべき倫理指針に関する倫理委員会の審査が済んでいる場合は、「審査済み」にチェックし一部若しくは全部の審査が完了していない場合は、「未審査」にチェックすること。

その他（特記事項）

（※2）未審査に場合は、その理由を記載すること。
（※3）廃止前の「疫学研究に関する倫理指針」、「臨床研究に関する倫理指針」、「ヒトゲノム・遺伝子解析研究に関する倫理指針」、「人を対象とする医学系研究に関する倫理指針」に準拠する場合は、当該項目に記入すること。

５．厚生労働分野の研究活動における不正行為への対応について

研究倫理教育の受講状況	受講 ■　未受講 □

６．利益相反の管理

当研究機関におけるＣＯＩの管理に関する規定の策定	有 ■　無 □(無の場合はその理由:　)
当研究機関におけるＣＯＩ委員会設置の有無	有 ■　無 □(無の場合は委託先機関:　)
当研究に係るＣＯＩについての報告・審査の有無	有 ■　無 □(無の場合はその理由:　)
当研究に係るＣＯＩについての指導・管理の有無	有 □　無 ■（有の場合はその内容：　）

（留意事項）　・該当する□にチェックを入れること。
・分担研究者の所属する機関の長も作成すること。

令和４年４月１５日

厚生労働大臣　殿

機関名　　日本医科大学

所属研究機関長　職　名　　学長

氏　名　　弦間　昭彦

次の職員の令和３年度厚生労働行政推進調査事業費の調査研究における、倫理審査状況及び利益相反等の管理については以下のとおりです。

１．研究事業名　　健康安全・危機管理対策総合研究事業

２．研究課題名　　『新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

３．研究者名　（所属部署・職名）　医学部　・　助教

（氏名・フリガナ）　阪本　太吾　・　サカモト　タイゴ

４．倫理審査の状況

	該当性の有無		左記で該当がある場合のみ記入（※1）		
	有	無	審査済み	審査した機関	未審査（※2）
人を対象とする生命科学･医学系研究に関する倫理指針（※3）	■	□	■	日本医科大学	□
遺伝子治療等臨床研究に関する指針	□	■	□		□
厚生労働省の所管する実施機関における動物実験等の実施に関する基本指針	□	■	□		□
その他、該当する倫理指針があれば記入すること（指針の名称：　）	□	■	□		□

（※1）当該研究者が当該研究を実施するに当たり遵守すべき倫理指針に関する倫理委員会の審査が済んでいる場合は、「審査済み」にチェックし一部若しくは全部の審査が完了していない場合は、「未審査」にチェックすること。

その他（特記事項）

（※2）未審査に場合は、その理由を記載すること。
（※3）廃止前の「疫学研究に関する倫理指針」、「臨床研究に関する倫理指針」、「ヒトゲノム・遺伝子解析研究に関する倫理指針」、「人を対象とする医学系研究に関する倫理指針」に準拠する場合は、当該項目に記入すること。

５．厚生労働分野の研究活動における不正行為への対応について

研究倫理教育の受講状況	受講 ■　　未受講 □

６．利益相反の管理

当研究機関におけるＣＯＩの管理に関する規定の策定	有 ■　無 □(無の場合はその理由:　)
当研究機関におけるＣＯＩ委員会設置の有無	有 ■　無 □(無の場合は委託先機関:　)
当研究に係るＣＯＩについての報告・審査の有無	有 ■　無 □(無の場合はその理由:　)
当研究に係るＣＯＩについての指導・管理の有無	有 □　無 ■（有の場合はその内容：　）

（留意事項）　・該当する□にチェックを入れること。
・分担研究者の所属する機関の長も作成すること。

令和４年３月３１日

厚生労働大臣 殿

機関名　　慶應義塾大学

所属研究機関長　職　名　　学長

氏　名　　伊藤　公平

次の職員の令和 3 年度厚生労働行政推進調査事業費補助金の調査研究における、倫理審査状況及び利益相反等の管理については以下のとおりです。

1．研究事業名　健康安全・危機管理対策総合研究事業

2．研究課題名　新しい生活様式』に即した環境因子の変化に伴う熱中症発症因子の検討

3．研究者名　（所属部局・職名）医学部・講師

（氏名・フリガナ）　林田　敬・ﾊﾔｼﾀﾞ ｹｲ

4．倫理審査の状況

	該当性の有無		左記で該当がある場合のみ記入 (※1)		
	有	無	審査済み	審査した機関	未審査 (※2)
人を対象とする生命科学・医学系研究に関する倫理指針	□	■	□		□
遺伝子治療等臨床研究に関する指針	□	■	□		□
厚生労働省の所管する実施機関における動物実験等の実施に関する基本指針	□	■	□		□
その他、該当する倫理指針があれば記入すること（指針の名称：　）	□	■	□		□

(※1) 当該研究者が当該研究を実施するに当たり遵守すべき倫理指針に関する倫理委員会の審査が済んでいる場合は、「審査済み」にチェックし一部若しくは全部の審査が完了していない場合は、「未審査」にチェックすること。

その他（特記事項）

(※2) 未審査に場合は、その理由を記載すること。
(※3) 廃止前の「疫学研究に関する倫理指針」や「臨床研究に関する倫理指針」に準拠する場合は、当該項目に記入すること。

5．厚生労働分野の研究活動における不正行為への対応について

研究倫理教育の受講状況	受講 ■　未受講 □

6．利益相反の管理

当研究機関におけるＣＯＩの管理に関する規定の策定	有 ■　無 □(無の場合はその理由：　)
当研究機関におけるＣＯＩ委員会設置の有無	有 ■　無 □(無の場合は委託先機関：　)
当研究に係るＣＯＩについての報告・審査の有無	有 ■　無 □(無の場合はその理由：　)
当研究に係るＣＯＩについての指導・管理の有無	有 □　無 ■（有の場合はその内容：　)

（留意事項）・該当する□にチェックを入れること。
・分担研究者の所属する機関の長も作成すること。

信濃町-5092