Review articles

Transgender people and occupational diving: a new challenge for diving physicians?

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Abstract

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The gender identity of transgender people is not fully aligned with their sex assigned at birth. It has been estimated that approximately 355 of 100,000 people in the general population consider themselves transgender. Transgender people are increasingly choosing to transition through gender-affirming hormone therapy, including treatment with testosterone or oestrogens and gender-affirming surgeries. Occupational diving is performed in a unique, highly hostile physiological environment. An occupational diver should be free of pulmonary, cardiovascular, neurological, and psychological risk factors that could increase the risk of diving-associated adverse events. Dive medical assessments can identify these risk factors. The increasing number of people openly identifying as transgender raises the likelihood that more will want to participate in occupational diving. To date, however, no guidelines have been specifically designed for safe occupational diving by transgender individuals. This review, involving 43 systematic reviews and/or meta-analyses, was therefore designed to assess the long-term health effects in transgender individuals and how these influence occupational diving. Although transgender people face some additional health risks that could affect occupational diving, these risks can be managed by adhering to regular occupational fitness-to-dive guidelines.

Introduction

In contrast to cisgender individuals, the gender of transgender individuals does not fully align with their sex assigned at birth.[1] A transgender man is an individual assigned female at birth who identifies as male, whereas a transgender woman is an individual assigned male at birth who identifies as female.[2] A 2016 meta-analysis assessing self-reported transgender identity, primarily in the United States, Europe, and Southeast Asia, estimated that 355 per 100,000 people in the general population identify as transgender.[3] In recent decades, the number of people openly identifying as transgender has increased markedly,[4] with a recent Canadian census reporting that the prevalence of transgender and non-binary individuals was five-fold higher in Generation Z, born between 1997 and 2006, than in the baby boomer generation, born between 1946 and 1965.[5] This increase may result from the greater social acceptance of people wishing to change gender and their increased opportunities for more appropriate medical care.[6]

Transgender people are increasingly choosing to transition through gender-affirming hormone therapy (GAHT) and gender-affirming surgeries (GAS). Although rates vary worldwide, it has been estimated that 9.2 per 100,000 people in the general population seek GAS or GAHT.[3] GAHT in transgender females consists of treatment with anti-androgens and oestrogens, whereas GAHT in transgender males consists of treatment with testosterone, possibly supplemented with progestins.[7] GAS also varies widely and can include gynaecological, urological, dermatological, plastic, and ear, nose, and throat (ENT) surgery.[7]

Diving involves work or recreation in a unique physiological environment. The human body is not adapted to an aquatic habitat and requires special equipment, such as diving gear, to function in this environment. Some individuals, however, are unable to dive. For example, individuals with pulmonary or cardiovascular diseases (CVD) are more likely to be found unfit to dive.[8] Individuals are subjected to a dive medical assessment to identify physical factors or conditions that increase the risk of developing underwater problems or divers' diseases. If this risk is deemed too high, the candidate will be rejected. The European Diving Technology Committee (EDTC) 2024 fitness-to-dive guidelines are considered the most current.[9] These guidelines, however, do not include assessments of transgender individuals.

The increasing prevalence of transgender people increases the likelihood that more of these individuals will wish to participate in diving, both professionally and recreationally. Dive medical physicians seek to offer all occupational divers a reliable dive medical assessment. These tests are limited by the lack of guidelines for the assessment of transgender divers. Because reference values are based on biological sex, it is essential to differentiate between 'gender,' based on self-identification as male or female, and 'sex,' based on the physical and genetic attributes of that person. The 'gender' values providing the lowest risk have not been determined, and the effects of undergoing hormonal therapy and / or gender reassignment surgery on the risk of developing diving diseases such as decompression illness have not been evaluated.

To date, there are no guidelines for safe occupational diving tailored to the transgender population. This review aims to provide recommendations for assessing diving medical fitness among transgender individuals based on an exhaustive survey of the relevant literature.

Methods

SEARCH STRATEGY

The current review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 checklist to find articles regarding long-term health effects in adult transgender people.[10] A search was initially performed in February 2024, but due to a new search strategy, it was repeated in February 2025. The PubMed, Embase, and Web of Science databases were searched for articles published between January 1, 2000, and December 31, 2024. The search strategy was customised for each database, combining search terms using Boolean operators such as 'OR', 'AND' and 'NOT.' The detailed search strategies are available in *Supplemental Table 1. The Rayyan web application (rayyan.ai) was utilised for the screening process.

DATA EXTRACTION

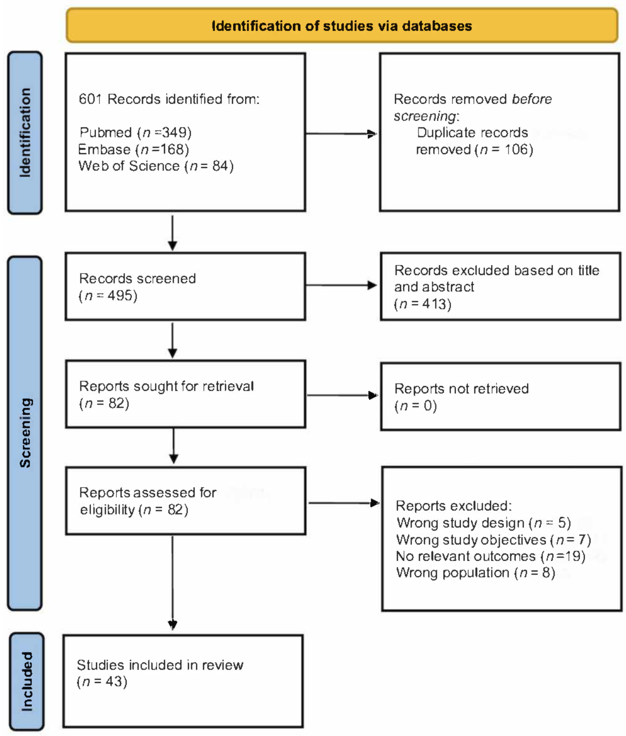
Two independent reviewers (PJVO and AB) were involved in the study selection. In case of uncertainty, decisions were made through discussion with a third reviewer (RVH). Systematic reviews and/or meta-analyses in English regarding the long-term health effects on transgender individuals were included. Other types of reviews, studies involving populations other than transgender individuals, and studies published in languages other than English were excluded.

Results

SEARCH AND ARTICLE INCLUSION

Figure 1 illustrates the inclusion and exclusion process. An electronic database search identified 601 studies. After removing duplicates, 495 studies were screened. A review of titles and abstracts excluded 413 of these studies, leaving 82 for further assessment of eligibility. A full reading of these articles resulted in the exclusion of 39 due to inadequate study design, seven for irrelevant study objectives, 19 for study outcomes unrelated to this review, and 14 for other reasons. Ultimately, 43 articles were included for further assessment.

Figure 1
PRISMA flow diagram showing an overview of the study selection process



*Footnote: Supplemental Table 1 is available online on our website https://www.dhmjournal.com/index.php/journals?id=399

CHARACTERISTICS OF INCLUDED STUDIES

The characteristics of the included articles are summarised in Table 1. Of these 43 included articles, 23 were systematic reviews, four were meta-analyses, and 16 were combined systematic reviews and meta-analyses (SRMAs). The 23 systematic reviews included six cardiovascular,[11–16] five psychosocial,[17–21] one locomotor,[22] one neurological,[23] and two endocrinological[24,25] reviews, as well as eight reviews on miscellaneous topics,[26–33] including breast cancer, sport performance, and changes in haemoglobin concentrations. The four meta-analyses included two cardiovascular,[34,35] one psychosocial[36] and one body composition[37] meta-analysis. The 16 combined SRMAs included seven cardiovascular,[38–44] one psychological,[45] three locomotor,[46–48] and one neurological[49] SRMA, as well as four SMRAs on miscellaneous topics,[50–53] including breast cancer and blood testing.

Assessing diving medical fitness among transgender individuals

Guidelines for the assessment of divers are criteria used to determine whether a diver is fit or unfit to dive, regardless of the diver's gender. The application of these guidelines to transgender divers, however, remains undetermined. The outcomes of the included studies were compared with the EDTC 2024 guidelines[9] to determine whether adjustments of these guidelines are required for transgender individuals.

PSYCHOSOCIAL

According to the EDTC 2024 guidelines, divers should have good mental stability. Any condition that causes mental instability might render these persons unfit to dive. Evaluations of a diver's mental fitness should not only consider the risk to the diver and those around them, but also the chance of recurrence of any psychiatric or psychological disorder or symptoms that could affect them. Special attention should be paid to the type of work, remote locations, and associated risks involved.[9]

The results of systematic reviews and meta-analyses on psychological functioning and quality of life in transgender individuals are inconsistent. Some studies showed that psychosocial functioning and quality of life improved after GAHT or GAS,[17,20,45] whereas one study found no improvements in quality of life, anxiety, and depression.[19]

Transgender individuals were found to use significantly more tobacco (odds ratio [OR] 1.58; 95% confidence interval [CI] 1.44–1.73) and specific substances such as cocaine, amphetamines or inhalants (OR 2.11; 95% CI 1.77–2.51).[36] Indeed, the rates of binge drinking and illicit drug use were observed to be higher in transgender than in cisgender individuals, indicating that transgender individuals are more at risk for problem drinking.[18]

Although the risks of tobacco use, alcohol consumption and illicit drug use, as well as rates of psychological disorders, such as depression and anxiety, are higher in transgender than in cisgender individuals, a person-by-person approach is essential when assessing a transgender individual. An additional in-depth psychological or psychiatric evaluation by a specialist with expertise in diving medicine might be necessary to decide whether a candidate is fit to dive.

PULMONOLOGY

In dive medical assessments, evaluating the pulmonary tract is paramount, as it is one of the main organ systems that must adapt to immersion.[9] Decreases in forced vital capacity (FVC), forced exhaled volume in one second (FEV_1), and the FEV_1/FVC ratio increase the risk of barotrauma. Unsurprisingly, pulmonary function testing (PFT) is essential in assessing medical fitness to dive. To exclude subjects with 'unfit lungs', PFT results are compared with a reference set, such as those of the Global Lung Function Initiative.[54] This reference set is, among other criteria, based on the gender of the subject.

The literature search did not identify any articles evaluating the long-term effects on the respiratory health of transgender individuals, suggesting that special adjustments are unnecessary for evaluating transgender divers. However, the European Respiratory Society recommends using the sex assigned at birth as the reference in evaluating PFT results, thereby avoiding underestimating risks in a female-to-male transgender person (FtM) or overestimating risks in a male-to-female transgender person (MtF).[55]

CARDIOVASCULAR

The EDTC 2024 guidelines regard all organic heart diseases, such as coronary heart disease and dysrhythmia, as potential reasons for rejection unless a cardiologist with a dive medical background decides otherwise.[9] Cardiac issues are a leading factor in diving accidents.[56] Older age, obesity and hypertension are factors associated with a higher risk of developing decompression sickness (DCS), and hypertension is also associated with an increased risk of developing immersion pulmonary oedema (IPO).[57] It is therefore vital to examine the cardiovascular system for potential cardiovascular diseases (CVD) in all divers, regardless of gender. Assessing cardiovascular risk factors should be included in the dive medical assessments of individuals aged over 35 years.[9]

Most systematic reviews and meta-analyses evaluating the cardiovascular system in FtM individuals have reported increases in the concentrations of low-density lipoproteins (LDL),[11,35,38,42,44] total cholesterol (TC)[35,42,44] and triglycerides (TG),[38] and a decrease in the concentration of high-density lipoproteins (HDL),[11,12,15,35,38,42] indicating a heightened risk of CVD.

Table 1

Summary of the characteristics of the included papers; BMD – bone mass density; BMI – body mass index; CI – confidence interval; CVD – cardiovascular disease; FtM – female-to-male transgender person; GAHT – gender-affirming hormone therapy; HDL – high-density lipoprotein; Hb – haemoglobin; Hct – haemocrit; INR – international normalised ratio test; LDL – low-density lipoprotein; MA – meta-analysis; MtF – male-to-female transgender person; NR – not reported; OR – odds ratio; QoL – quality of life; SIR – standardised incidence ratio; SR – systematic review; TC – total cholesterol; TG – transgender persons; TGL – triglycerides; VTE – venous thromboembolism; ↑ – increase; ↓ – decrease; ↔ – no increase/decrease

Ref	Type of study	Studies included	Population (*n*)	Primary findings/conclusion	Quality control	
					Risk of bias	Heterogeneity
				Cardiology		
11	SR	13	499 (FtM)	BMI↑, LDL↑, Hb↑, Hct↑, HDL↓	NR	NR
38	SR/ MA	29	3,231 (MtF) 1,500 (FtM)	FtM: TGL↑, LDL↑ MtF: TGL↑	Moderate	Low-considerable
12	SR	77	5,866 (MtF) 1,501 (FtM)	MtF: cardiometabolic morbity↑, thromboembolic morbidity↑ compared to cisgender females, ↔ compared to cisgender males. MtF/FtM: hypertension ↔, DM ↔ cisgender peers	NR	NR
39	SR/ MA	12	2,518 (MtF)	VTE risk = 2.3 per 1000 person-years	NR	Substantial
34	MA	18	11,542 (MtF)	MtF > 37.5 years or > 53 months GAHT: VTE risk is 3.0% and 1% respectively. MtF < 37.5 years or < 53 months GAHT: VTE risk is neglectable	Low	Considerable
13	SR	14	648 (MtF) 661 (FtM)	FtM: blood pressure ↔. MtF: ambiguous result regarding blood pressure	Moderate-serious	NR
14	SR	11	6,068 (MtF) 3,112 (FtM)	MtF: VTE risk 42.6:10.000 patients, ↑ than cisgender females FtM: VTE risk 10.8:10.000 patients equal to cisgender males	Moderate-serious	Substantial
15	SR	11	471 (FtM)	HDL↓, LDL inconsistent results	Serious	NR
40	SR/ MA	22	19,893 (MtF) 14,840 (FtM)	Transgender people have a 40% higher risk of CVD compared with cisgender peers	Serious-critical	Substantial (MtF) Moderate (FtM)
41	SR/ MA	7	312 (FtM)	FtM: Hct ↑ (4.39 [3.25–5.26]), Hb ↑ (1.48 [1.17–1.78]), INR ↑ (0.02 [0.01–0.03]).	Moderate	Low-moderate
42	SR/ MA	35	1,305 (MtF) 1,336 (FtM)	FtM: LDL↑ (26.2mg·dl^{-1}), TC ↑ (26.1mg·dl^{-1}), TGL ↑ (30.7mg·dl^{-1}), HDL ↓ (-9.4mg·dl^{-1}) MtF: HDL ↔, TGL ↔, LDL and TC inconsistent results	Moderate-serious	Low-considerable
16	SR	18	2,080 (MtF)	Hct ↑. Smoking, higher age at initiation of testosterone therapy, higher BMI, and a predisposing medical history associated with increased Hct	Low-moderate	NR
43	SR/ MA	35	2,752 (MtF)	BMI ↑ (0.46 kg·m^{-2}), LDL ↓ (6.67 mg·dl^{-1}), systolic blood pressure ↓ (-3.69 mmHg)	Low-moderate	Low
44	SR/ MA	24	992 (MtF) 1,241 (FtM)	FtM: LDL ↑ (0.28 mg·dl^{-1}), TGL ↑ (0.42 mg·dl^{-1}), TC ↑ (0.17 mg·dl^{-1}), HDL ↓ (-0.50 mg·dl^{-1}), BMI ↑ (0.24 kg·m^{-2}), blood pressure ↔ MtF: TGL ↑ (0.64 mg·dl^{-1}), LDL ↔, HDL ↔, TC ↔, blood pressure ↔, BMI ↔	Serious	Considerable
35	MA	39	1,949 (FtM)	FtM: BMI ↑ (0.78 kg·m^{-2}), weight ↑ (2.20 kg), body fat ↓ (-1.29 kg), TC ↑ (4.95 mg·dl^{-1}), HDL ↓ (-7.52 mg·dl^{-1}), LDL ↑ (11.15 mg·dl^{-1}), TGL↑ (9.49 mg·dl^{-1}), blood glucose ↓ (-2.06 mg·dl^{-1})	Moderate	Low

Table 1 continued.

Psychosocial						
17	SR	3	237 (TG)	3–12 months after hormone therapy psychosocial functioning and QoL improved in both FtM and MtF transgender individuals	Moderate-serious	Low
18	SR	41	23,191 (TG)	Transgender people are more likely to engage in binge drinking and are at increased risk for problematic drinking and illicit drug use than cisgender individuals	Low-moderate	Substantial
45	SR/ MA	29	421 (MtF) 164 (FtM)	TG mental QoL ↓ (-0.78) compared with the general population. Post-treatment mental QoL ↔ compared with the general population	Moderate-high	Substantial
19	SR	7	552 (TG)	QoL ↔, anxiety ↔, depression ↔	Low-moderate	NR
20	SR	33	2,253 (MtF) 8,095 (FtM)	Gender-affirming surgery may lead to multiple psychological benefits	NR	NR
36	MA	20	18,329 (TG)	Compared with cisgender individuals, tobacco↑ (OR) = 1.65), previous substances use ↑ (OR = 1.48), present specific substances use ↑ (OR = 1.79)	Low-moderate	Low
21	SR	19	NR	Transgender veterans and service members experience worse mental health outcomes than their cisgender counterparts	NR	NR
Locomotor						
46	SR/ MA	13	392 (MtF) 247 (FtM)	FtM: BMD lumbar spine ↔, femoral neck ↔, total hip ↔ MtF: BMD lumbar spine ↑ (0.06 g·cm2), femoral neck↔, total hip ↔, fracture rates ↔	Moderate	Low (FtM) Low-substantial (MtF)
47	SR/ MA	19	812 (MtF) 487 (FtM)	GAHT did not affect bone density in FtM and affected bone density only at the lumbar spine in MtF	Low-moderate	Low-considerable (control studies)
22	SR	9	912 (MtF) 719 (FtM)	Longterm effect: BMD MtF ↓, FtM ↔. MtF and FtM: Calcium ↔, phosphate ↔, alkine phosphate ↔, osteocalcin ↔	Moderate	NR
48	SR/ MA	14	1,484 (FtM)	No significant changes were observed in BMD, calcium, phosphate, vitamin D, parathyroid hormone, or other analysed bone turnover markers	Moderate	Low – substantial
Neurology						
49	SR/ MA	14	8,014 (MtF)	Incidence of 2% for cerebrovascular events	Low-moderate	Substantial
23	SR	9	47 (MtF)	Increased intracranial meningioma risk when using > 25 mg/day cyproterone acetate	Moderate	NR
Endocrinology						
24	SR	26	689 (MtF) 751 (FtM)	FtM: lean body mass ↑, fat ↓, insulin resistance ↔ MtF: lean mass ↓, fat ↑, insulin resistance ↑	NR	NR
25	SR	11	6,211 (MtF) 4,838 (FtM)	TG: BMI ↑, insulin resistance ↑ (more in MtF than FtM)	Low	NR
Physical performance						
26	SR	8	147 (TG)	One-year post-cross hormone therapy FtM are likely to compete without an athletic advantage. This also applies to MtF who also take testosterone blockers, although they still may have greater muscle mass	NR	NR

Table 1 continued.

37	MA	10	171 (MtF) 354 (FtM)	MtF: body weight ↑ (1.8 kg), body fat ↑ (3.0 kg), lean body mass ↓ (-2.4 kg) FtM: body weight ↑ (1.7 kg), body fat ↓ (-2.6 kg), lean body mass ↑ (3.9 kg)	Low	Substantial – considerable
32	SR	24	1,829 (MtF)	MtF: Hb decreased but ended equal to cisgender females. Lean body mass, total body fat, and muscle strengths higher than in cisgender females	Moderate	NR
Cancer						
27	SR	26	22 (MtF)	The risk of breast cancer is low, but when present occurs in younger patients	Moderate	NR
28	SR	8	17 (FtM)	FtM transgender individuals have a lower risk of breast cancer than cisgender females (44.5 yrs vs. 62 yrs)	Moderate-high	NR
29	SR	43	31 (MtF) 28 (FtM)	FtM: breast cancer comparable to cis-males (5.9 vs. 1.2 per 100,000 person-years), lower than cis-females (170 per 100,000 person-years). Ovarian, vaginal, uterine and cervical cancer not found. MtF: breast cancer comparable to cis-males (4.3 per 100,000 person-years). Prostate cancers lower (0.04%) than in cis-males. GAHT has not been shown to affect cancer risk	Serious	NR
30	SR	43	8,384 (MtF) 3,028 (FtM)	GAHT not significantly related to risk of cancer or cancer related deaths although mortality lower in MtF individuals	NR	NR
31	SR	22	23 (FtM)	FtM: lower risk of breast cancer than in cisgender females but higher than that in cisgender males.	Low-moderate	NR
33	SR	76	31 (FtM)	FtM: breast cancer risk ↑ than in cisgender men ↓ than in cisgender women. Breast cancers been diagnosed at a younger age than in cisgender women and cisgender men	Low-Serious	NR
51	SR/ MA	41	6,166 (MtF) 6,604 (FtM)	FtM (SIR = 63.4) and MtF (SIR = 22.5) individuals are at higher risk of developing breast cancer than cisgender men, but lower risk than in cisgender women (SIR = 0.42 vs. 0.30)	NR	Low-substantial
52	SR/ MA	14	1,864 (MtF)	MtF: breast augmentation is overall a safe procedure but higher risk of early (haematoma 0.63%) and longer term (implant malposition 3.89%) complications than in cisgender females	Low	Low-substantial
Miscellaneous						
50	SR/ MA	26	1,455 (MtF) 1,386 (FtM)	FtM: creatinine ↑ (0.15 $mg\cdot dl^{-1}$) MtF: creatinine ↔	Moderate-high	Low
53	SR/ MA	16	2,758 (FtM)	Alanine-aminotransferase initially increases (OR 2.31; 95% CI 1.41–3.21), but stabilises as early as 24 months (OR 1.71; 95% CI -0.02–3.44)	Moderate	Low-substantial

Indeed, a recent study analysing 22 articles showed that FtM individuals are at higher risks of venous thromboembolism (VTE; OR 1.4) and myocardial infarction (OR 1.7) than cisgender individuals.[40] More importantly, the risk of CVD death was more than two-fold higher in FtM than in cisgender individuals (OR 2.2).[40]

Several systematic reviews and meta-analyses in MtF individuals have shown increases in the concentrations of HDL,[12] TC,[42] and TG,[12,38,44] and a reduction in the concentration of LDL,[12,43] indicating that MtF individuals have a more protective lipid profile than FtM persons. However, the risk of VTE was more than two-fold higher in MtF that in cisgender individuals (OR 2.2),[40] especially in those aged > 37.5 years or using GAHT for > 53 months.[34] Moreover, the risk of CVD death was found to be higher in MtF than in cisgender individuals (OR 1.5).[40]

Only six studies to date have reported the effect of GAHT on blood pressure.[11–13,15,43,44] Although systolic and diastolic blood pressure tended to increase in FtM and decrease in MtF individuals, no definitive conclusions could be drawn, either because the differences were not statistically significant or because the studies were of low to moderate quality.

Taken together, these findings suggest that transgender individuals may be at higher risk for CVDs, particularly after age 37 years. Because the EDTC recommends that divers aged ≥ 35 years undergo cardiovascular risk management (CVRM), there is no need for additional screening of a transgender occupational diver. Although CVRM risk score calculators like QRISK3 may be useful,[58] these risk calculators were designed for cisgender individuals. It is therefore unclear whether the reference for transgender individuals should be based on their cisgender or transgender peers.

NEUROLOGY

Because neurological diseases can imitate decompression illnesses or compromise diver safety, a thorough assessment of the neurological system is crucial. A diver's medical history, combined with a neurological examination, should be part of the initial and annual evaluations. Any neurological disease that affects a diver's consciousness or leads to a sudden impairment might have an impact on their fitness to dive. Divers with pre-existing neurological disorders, therefore, require careful evaluation.[9]

Only two of the 43 included papers examined the long-term neurological health effects on transgender individuals. One study reported that the prevalence of cerebrovascular events in MtF individuals was 2%, which is lower than the worldwide stroke risk.[49] The second study examined the long-term effects of cyproterone acetate on neurological pathway. MtF individuals who used high doses of cyproterone acetate were found to have a higher risk of intracranial meningiomas. Although the overall risk of meningiomas in transgender people was very low, multiple meningiomas occurred more often than in the cisgender population. At its recommended dose of 10 mg, however, cyproterone acetate did not increase the risk of meningiomas.[23]

These findings suggest that transgender individuals are not at a higher risk of neurological diseases that could affect their ability to dive. Therefore, the neurologic recommendations in the EDTC guidelines are sufficient for assessing transgender divers.[9]

EAR, NOSE AND THROAT (ENT)

ENT-related diving diseases are by far the most common injuries in diving, with most associated with dis-equalisation of the middle ear or sinuses. Thus, a suitable working equalisation technique is important.

Besides hormones, gender-affirmation surgery often plays a role in the transition to the desired gender. ENT-related gender-affirmation surgery (ERGAS) can include rhinoplasty, bone and soft-tissue reconstruction, forehead contouring, hairline adjustment, brow lift, lip lift, mandibular shaping, genioplasty, vocal cord surgery, and chondrolaryngoplasty.[59]

The search of the relevant literature did not identify any systematic review or meta-analysis on the long-term health effects of ERGAS on the ENT tract. Although some aspects of ERGAS may have consequences for diving, these problems are unlikely to occur. The EDTC guidelines should therefore be sufficient for assessing transgender divers.[9]

INTERNAL ORGANS

Depending on the signs or symptoms, endocrine disorders can pose a risk to the diver. For examples, disturbances of consciousness, cardiac arrhythmias and decreased exercise capacity can incapacitate a diver, and diseases such as phaeochromocytoma, Addison's disease, and diabetes mellitus may be incompatible with occupational diving. Dive medical physicians should therefore consult specialists for advice before determining whether an individual is fit to dive.[9]

To date, three systematic reviews and one meta-analysis have evaluated the effects of GAHT on insulin resistance and the prevalence of diabetes mellitus. One study found no significant differences in insulin resistance between transgender and cisgender individuals,[12] whereas a second study found that rates of insulin resistance did not differ in FtM and cisgender individuals, whereas the results were inconclusive in MtF individuals.[24] Insulin levels did not differ significantly in FtM and cisgender individuals,[35] and no differences were observed in the prevalence of type 2 diabetes mellitus in transgender and cisgender populations.[25]

The concentration of alanine-aminotransferase in FtM individuals was found to increase during the first two years of GAHT (OR 1.71, 95% CI -0.02–3.44). Although statistically significant, this increase was not clinically significant, indicating that GAHT does not impair liver function during the first 24 months of treatment.[53] GAHT for 12 months was associated with an increase in serum creatinine in FtM, but not in MtF individuals, suggesting a decrease in kidney function in the former.[50] None of the included systematic reviews and/or meta-analyses reported that GAHT had any other long-term health effects on internal organs. Taken together, these findings indicate that the EDTC guidelines on internal organs are sufficient for transgender divers, with no additional specific tests being necessary.

PHYSICAL PERFORMANCE AND MUSCULOSKELETAL TRACT

According to the EDTC guidelines, the physical demands for occupational diving range from 3 to 13 METs, where one MET equals 3.5 ml $O_2.kg^{-1}.min^{-1}$ for males and 3.2 ml $O_2.kg^{-1}.min^{-1}$ for females. Although different tasks require varying physical demands, the EDTC guidelines recommend a minimum physical capacity of 12 METs. Divers with a physical capacity between 8 and 11 METs may, however, be deemed fit to dive if this capacity is compatible with the demands of the task.[9] Moreover, strength may be more important than physical endurance in underwater construction work, emphasising the fit-for-the-job principle. Finally, the EDTC guidelines do not differentiate between genders.

To date, only one systematic review has examined the effects of GAHT on physical performance in transgender individuals. Muscle mass in FtM individuals using GAHT was found to be comparable to that in cisgender males.[26] Although muscle mass decreased in MtF individuals using GAHT, it was significantly higher than that in cisgender females.[26] Because no review has assessed the impact of GAHT on athletic performance levels, it is difficult to compare physical endurance in the transgender and cisgender populations.

Physical performance and strength are also influenced by body composition, haemoglobin (Hb) and haematocrit (Hct) levels. High body weight resulting from a high percentage of body fat or a lower lean body mass can reduce maximal oxygen uptake (VO_2-max). GAHT, particularly in MtF individuals, can result in increased body weight and/or reduced lean body mass.[37] Lower Hb and Hct levels can result in reduced physical endurance, as observed after whole blood donation.[60] FtM individuals have shown increases in Hb and Hct, to levels similar to those of cisgender males, likely resulting in improved physical endurance.[11,16,41] By contrast, MtF individuals have shown reductions in Hb and Hct, with Hct levels close to those of cisgender females.[32] GAHT did not significantly affect bone mass density in either FtM or MtF individuals.[22,46–48]

Although physical strength and performance are vital for an occupational diver, and GAHT might influence both in various ways, there is no reason to deviate from the current EDTC guidelines.[9] Regardless of gender, individuals must meet the minimum requirements.

CANCER

Any form of cancer can lead to temporary or permanent disqualification from diving. Depending on the type of cancer, the treatment received, and the presence of disability, the dive medical physician must determine whether an individual is fit to continue occupational diving. These decisions are made on a case-by-case basis.[9]

Seven systematic reviews have assessed the effect of GAHT on cancer development. Generally, GAHT does not influence cancer risk.[29] The risk of breast cancer in MtF individuals has been reported to range from 4.1–20 per 100,000, roughly similar to the risk in cisgender males but lower than in cisgender females.[27,29,33,51] Breast cancer, however, occurred at a younger age in MtF (approximately 51 years) than in cisgender individuals.[27,33] The risk of breast cancer in FtM individuals was similar to that in cisgender males but lower than that in cisgender females.[28,29,31,51] Ovarian and uterine cancers have not been observed to date in FtM individuals,[29] whereas the risk of prostate cancer was lower in MtF individuals than in cisgender males.[29]

Because many factors affect the fitness to dive after a cancer diagnosis, each person must be assessed individually. The EDTC guidelines do not require modification when assessing a transgender diver who was diagnosed with cancer.

Discussion

To our knowledge, this is the first review evaluating transgender occupational divers. Although these individuals may face some increased health risks, there is no need to modify the current fitness-to-dive guidelines. These additional health risks can be addressed by following the proper guidelines.

To date, only one case report has evaluated a transgender diver, an MtF person who transitioned during her career as a diver.[61] Although the potential DCI risk was discussed, the lack of data on DCI risk among transgender divers required application of the risk for female divers to this MtF diver. Based on French law, the company employing the MtF diver was advised to restrict her diving activities to those permitted by French legislation, such as wearing weights of no more than 25 kg. Because of a possible increased risk of CVD, blood tests, including measurements of Hb and glucose concentrations and evaluation of lipidaemia, were recommended every three months. By contrast, the EDTC guidelines regarding the risk of CVRM do not recommend quarterly blood tests.[9]

Although there is no need to modify the EDTC guidelines when assessing a transgender diver, dive medical physicians should be aware of other issues not related to assessment. The psychosocial aspect of being transgender in a predominantly male world of occupational diving should be considered. Employers are required to create a physically and psychologically safe working environment. Dive medical physicians, in close cooperation with occupational physicians, should therefore provide diving companies with recommendations on this aspect of diving.

This review has several strengths, such as being the first to evaluate the assessment of occupational transgender divers, the systematised search protocol and its relevance to occupational diving. However, this review also had several limitations. First, the quality of the included papers varied markedly. Most of the reviews and meta-analyses included showed a moderate to considerable level of heterogeneity, indicating that the data within these studies were inconsistent. Therefore, even statistically significant outcomes may not have been clinically meaningful. Additionally, the quality of the included articles was not evaluated systematically, leading to the inclusion of studies with low to moderate quality. This may have limited the validity of some outcomes and the potential for selective reporting of long-term health effects in transgender individuals. More importantly, some studies lacked detailed information regarding the characteristics of the population. Nonetheless, comparisons of the results of the included systematic reviews and meta-analyses by topic showed insubstantial differences in the reported outcomes. Thus, although the risks of bias and heterogeneity may have influenced the results, they did not significantly affect the overall conclusion.

Second, the search included only systematic reviews and meta-analyses, excluding other types of reviews and non-review articles. This search strategy may therefore have been too narrow, missing important information from other publications. However, based on the methodological approach of conducting systematic reviews and/or meta-analyses, the key papers for this review were likely included. Examination of the references cited in the included reviews and meta-analyses showed substantial overlaps, suggesting that important information from other, non-included literature sources was not overlooked.

Thirdly, the search was limited to systematic reviews and meta-analyses written in English, which may have led to omission of relevant studies published in other languages and influenced the results of this review. English, however, is the primary language used in scientific publications, suggesting that significant findings would likely have been published in English. Although this publication bias could not be entirely eliminated, it likely had no effect on the results of this analysis.

Finally, this review was concentrated on occupational diving, which has more stringent fitness-to-dive guidelines than recreational diving. Therefore, the present findings cannot be directly applied to fitness-to-dive guidelines for recreational diving. However, diving medicine physicians who assess recreational divers might adapt the results of this review to recreational divers.

The present study found that current fitness-to-dive guidelines are adequate for assessing transgender divers involved in occupational underwater or caisson work. Further research focused on occupational diving is required, however, to ensure that transgender divers can continue to dive safely. Outcomes of these studies may result in alterations to current fitness to dive guidelines.

Conclusions

Worldwide, the number of people openly identifying as transgender is increasing. This may result in an increase in the number of transgender occupational divers asking dive medical physicians for fitness-to-dive assessments. To date, specific fitness to dive guidelines have not been formulated for transgender persons. The results of this systematic review suggest that, although transgender divers are at higher risk of long-term health effects from GAHT, such as cardiovascular issues, the likelihood that these health effects have an impact on diving can largely be reduced by adhering to regular fitness-to-dive guidelines, such as the EDTC guidelines.

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